REINFORCED CONCRETE FIELD HANDBOOK

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A. E. Rounce

Toronto

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REINFORCED CONCRETE FIELD HANDBOOK

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Reinforced Concrete Field Handbook

Construction Data for Office and Work

This book is published in response to a demand for the latest experience in field work put into few words for pocket use, eliminating all but essentials. The subject matter following is laid out and grouped under three main heads.

MATERIALS OF CONSTRUCTION — Concrete.
Cement.
Sand.
Aggregate.
Steel (Material.)

METHODS OF CONSTRUCTION — Centering (Assembling and Dissembling.)
Steel (Fabrication and placing.)
Manufacture of Concrete.

CONSTRUCTION ORGANIZATION AND FIELD NOTES

CEMENT.

Cement as it is received on the work, is well known as a fine, almost impalpable grayish powder. The one necessity, which on construction work becomes almost second nature, is to "keep the cement dry" in handling and storing.

Portland Cement is an artificial mixture in certain well defined proportions established by practice, of lime, silica, alumina and other substances in minor quantities. Lime, mixed and calcined with clay, has the property of setting under water. A natural cement is made from rocky conglomerates which may contain the approximate quantities required, and which varies in its properties as the constituents of the natural deposits vary in proportion. Portland cement on the other hand is an exact artificial composition in proportions determined by analysis and experiment.

Clay is composed of silica (SiO_2) which is finely powdered quartz sand, together with alumina, and iron oxide. In a clay which is best suited for cement the amount of silica should be about three times the quantity of the alumina and ferric oxide combined.

We have the following approximate proportions of ingredients in every 100 parts of Portland cement:

Limestone	Lime ($CaCO_3$)	60 to 65 parts
Clay 29 to 36 parts	Silica (SiO_2)	21 to 24 parts
	Alumina (Al_2O_3)	6 to 8 parts
	Iron Oxide (Fe_2O_3)	2 to 4 parts

These are the principal components. There are also present in proportions stated:

Magnesia from ½ of one part to 2 parts.

Sulphuric acid from ½ of one part to 1½ parts.

Carbonic acid and water 1 part to 3 parts.

These last three are unimportant except when they are too evident by their presence, and are generally considered as impurities.

These materials thoroughly mixed, are then burned in a kiln, using either powdered coal, oil or gas flames under pressure. After the fused clinker or burned product is cooled, it is ground very fine, stored in bins for a required time, and is then ready to ship.

SAND.

In all our ideas of the use of cement, sand enters as an essential constituent, and an elementary understanding of its qualities, good and bad, is necessary. We can apply the term "sand" to any finely divided material, which will not disintegrate or decay, and which can be used with cement to make this filler. The common term in specifications is that "sand must be clean, sharp and coarse." A rough field test for percentage of loam is to rub the damp sand between your palms, and then see how much loam you can scrape off. Put a handful on a piece of glass or a piece of clean writ-

ing paper and place it in the sun, or near a heater to dry. White paper is best, for that can be rolled back and forth, and leave the fine loam on the edge. Crunch the sand in your hand near the ear, to determine whether it is sharp. Keep a magnifying glass on the work to examine sand.

In the laboratory for testing the material used in the Philadelphia subway construction the percentage of "loam" (which might better be termed "silt"), in the finer aggregates, was determined by agitating the sample in water, pouring off the water containing the matter not settled within three-quarters of a minute, and repeating the operation until the water became clear in that time. The effluent containing the suspended matter is poured into a glass cylinder into which the matter which settled in three-quarters of a minute had been previously placed, and after settlement the fine material is measured and recorded as a percentage of the total volume of the material in the glass cylinder, after the water has become clear.

AGGREGATES.

The different rocks used to produce concrete aggregate are:

Trap.—Very good, hard and with sharp faces. This includes crushed granite and other igneous rock.

Limestone.—Good for some kinds of work, not as hard as granite. Don't use where exposure to fire is possible, because heat will free the carbon dixoide (Co_2) from the limestone ($CaCo_3$) and leave quicklime CaO, which is slaked and disintegrated by water.

Sandstone.—Don't use sandstone unless it is tough and close grained.

Gravel.—A well graded bank gravel is excellent. The proportions of larger and smaller inerts is already well determined. A washed gravel is very good. If gravel runs too high in sand it should be screened.

Slag.—Furnace slag is specially prepared by running

the molten slag into large cisterns of water. This partly disintegrates it and corrects the sulphur and other chemicals. It can then be handled by a bucket, and is conveyed to the crusher. Crushed to any size, and used either screened or as "run of crusher" it makes an excellent concrete aggregate. With practically the same compressive strength, it is 15 to 20 per cent lighter than a rock concrete.

Cinders.—Cinders are liable to contain sulphur and other steel-corroding chemicals, also unburt coal, soot, ashes and dirt. If you use cinders, watch the quality. Screening to remove what impurities you can is only a fair precaution. Cinder concrete does not possess as much compressive strength as other concrete, but weighs considerably less, and consequently is suitable for roofs, fill between floor sleepers and so forth.

STEEL.

The reinforcing steel used is made by either the Open Hearth or the Bessemer process, which are terms used in the steel trade to designate the two methods by which steel is produced. In the Open Hearth process the correct proportions of iron, carbon, scrap, etc., are melted and refined in large furnaces. In the Bessemer process, pig iron is reduced to steel in a converter, using highly heated gases and air under pressure.

Open Hearth steel is usually on the market as a medium steel, with an ultimate tensile strength of 60,000 to 70,000 lb. per square inch. The elastic limit is between 35,000 and 40,000 lb.

The Bessemer steel usually has a higher ultimate strength, between 80,000 and 90,000 lb.

Reinforcing steel can be classed as *plain or deformed.* Plain steel refers to bars rolled in round or square sections. Deformed steel refers to the above steel rolled to a special pattern in order to secure a mechanical bond with the surrounding concrete. These

rollings are covered by patents and necessitate royalties, which increase the cost of the steel from $2 up per ton.

A plain square bar twisted is generally accepted as furnishing a mechanical bond. This can be either what is known as *cold-twisted* or *hot-twisted.* To reduce this discussion to what the user of this handbook will in most cases receive on the work, we find that there are in most general use four types of steel:

A.—Plain square or round mild Open Hearth.

B.—Plain square or round *Rerolled Bessemer.*

C.—Twisted square (A)—"Cold Twisted."

D.—Twisted square (B)—"Hot Twisted."

Relative to "rerolled," this is a term applied to bars rerolled from the heads of railroad rails which are out of service. The rails are bought by the rerolling mills at a very low ton price, and are reheated, split, and the different parts rolled into shapes such as angles or flats. The heads are generally used for reinforcing bars.

It is perhaps pertinent to introduce at this point a discussion of the market cost of steel. This of course varies with trade conditions, but today the price on Open Hearth steel (A and material of C) is $1.40 per carload lots, base F. O. B. Pittsburg. By "base" is meant all sizes from ¾-in. to 3-in. inclusive. The schedule in the table, "Differential for Size," shows the regular association extras, for sizes below ¾ in.

Cold twisting increases the cost of this material from 10c per cwt. ($2 per ton) or more, depending upon conditions.

The price on rerolled plain material is $1.30 per cwt., carload lots, base, Pittsburg. Hot twisted carries a 10c increase, making it cost $1.40 carload lots, base, Pittsburg. These prices are for the season of 1908, and are of course subject to change.

FORMS FOR REINFORCED CONCRETE.

This discussion of forms is based upon the needs of the superintendent and the carpenter foreman in the field, and an endeavor will be made to present the subject in a very simple way.

In the first place economy is the great consideration, economy in erecting forms, economy in taking down, economy in the cost of lumber, which is not always synonymous with cheapness in first cost. This latter item, however, concerns more the purchasing end of contracting. The lumber best adapted is white pine, yellow pine and spruce. Hemlock should not be used except for rough work, as in footings or retaining walls, or when absolutely necessary.

Use judgment and comprehension in receiving and placing material on the work. As the lumber comes to the job, pile it where it can be handled into the saw mill or framing yard with the least amount of labor. In stacking lumber leave spaces in the pile for drying, and always lap and pitch the top layer to shed water. Pile lumber in the shade when possible.

Floor Centering.—In preparing lumber for erection, the work is laid out according to the foreman's judgment, but in erecting the forms there is practically but one order, viz., the column forms are erected first, then follow the bottoms for the girders, bottoms for the beams, the girder and beam sides, the joists or stringers for the floor sheeting and lastly the sheeting itself. The forms are then ready for the steel and the concrete.

Design the girder forms to rest on the column forms. It will be necessary to remove the latter before the forms. In addition, this practice will save shores. Design the beam forms to rest on the girder or column forms and the slab centering to rest on the beam forms. Above all, good practice requires such a design of the centering that it can all be taken down without disturbing the shores and bottoms under the

FIG. 1.—PLAN OF TYPICAL REINFORCED CONCRETE FLOOR PANEL.

beams and girders. Green concrete beams and girders should not be required to bear any loads for a considerable period, hence the necessity to leave their supports in place undisturbed.

All lumber except that for shoring and bracing should be surfaced at least on one side and the edges. It is better to have chamfered corners of girders and columns, although in many cases it is not necessary. This is done by placing triangular pieces in the forms tacked lightly in place.

Avoid excessive use of nails. Nails must be used to batten together the pieces in a girder side, or in a column side, in forming panels where necessary, and in many other ways. But for braces or cleats or other parts which must be torn apart, especially when lumber must be used over and over again, use as few and as small nails as possible to diminish the labor cost and increase the life of the lumber.

Column forms have to resist very great pressures due to the depth and weight of wet concrete. They should be made of 2-in. stuff and held together by collars made of 2 x 4-in. pieces, four such pieces being necessary for a collar. They are cut considerably longer than the outside dimension of the column box so that they overlap and are fastened by nailing blocks on the ends and by wedges. These are very easily assembled and knocked down. They should not be more than 24 in. on centers vertically. Long bolts, holding together collar pieces on opposite sides may be used, but will be expensive except on very large jobs.

Sheet metal column forms are rapidly coming into use for circular columns. They are high in first cost, but are easily handled besides being adapted to use for several sizes of columns if properly designed. They are used in sections so as to be adjusted without difficulty to any length of column by overlapping sections. They are restrained against bursting pressures by

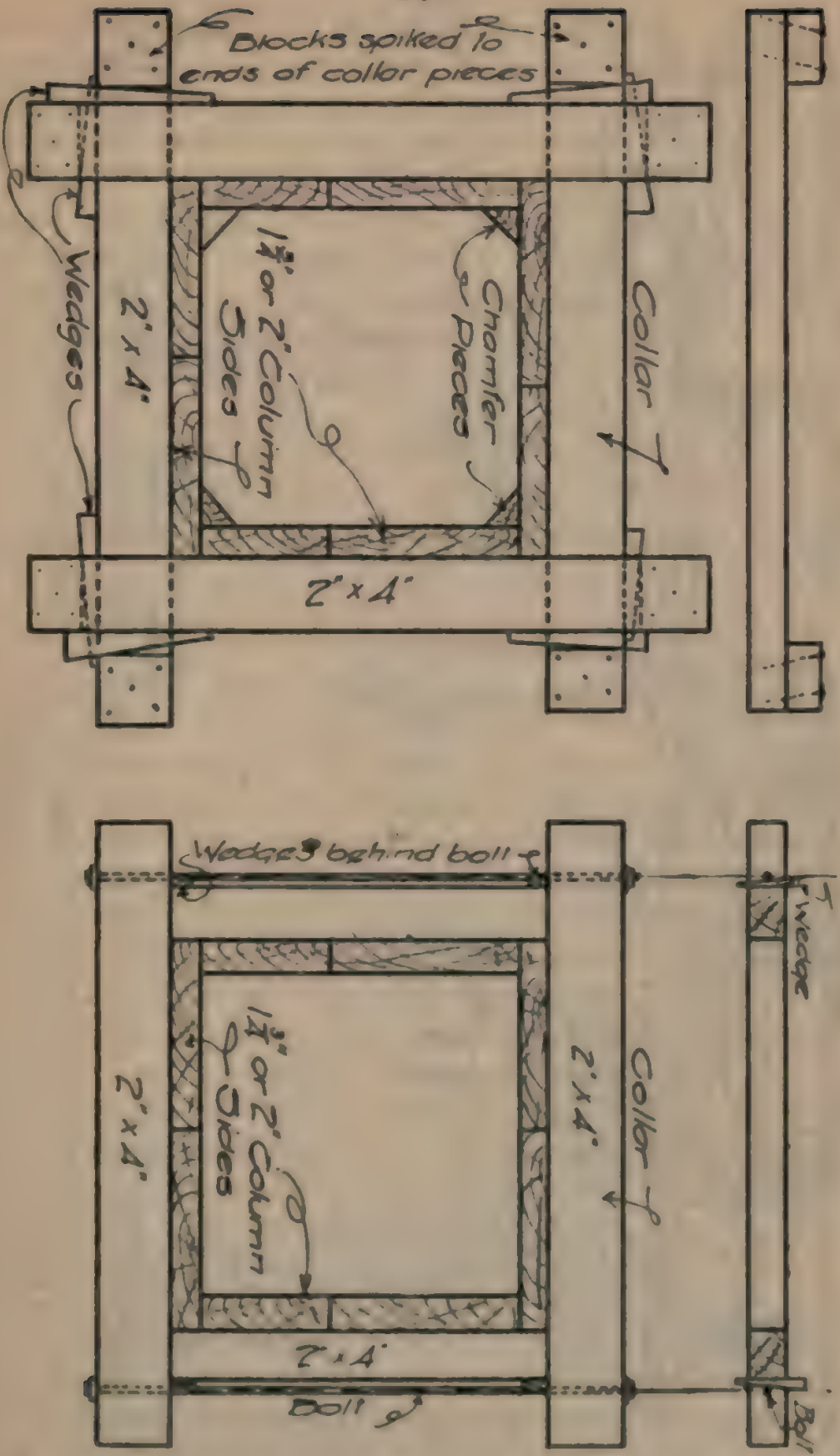


FIG. 2.—TWO TYPES OF COLLARS FOR COLUMN FORMS.

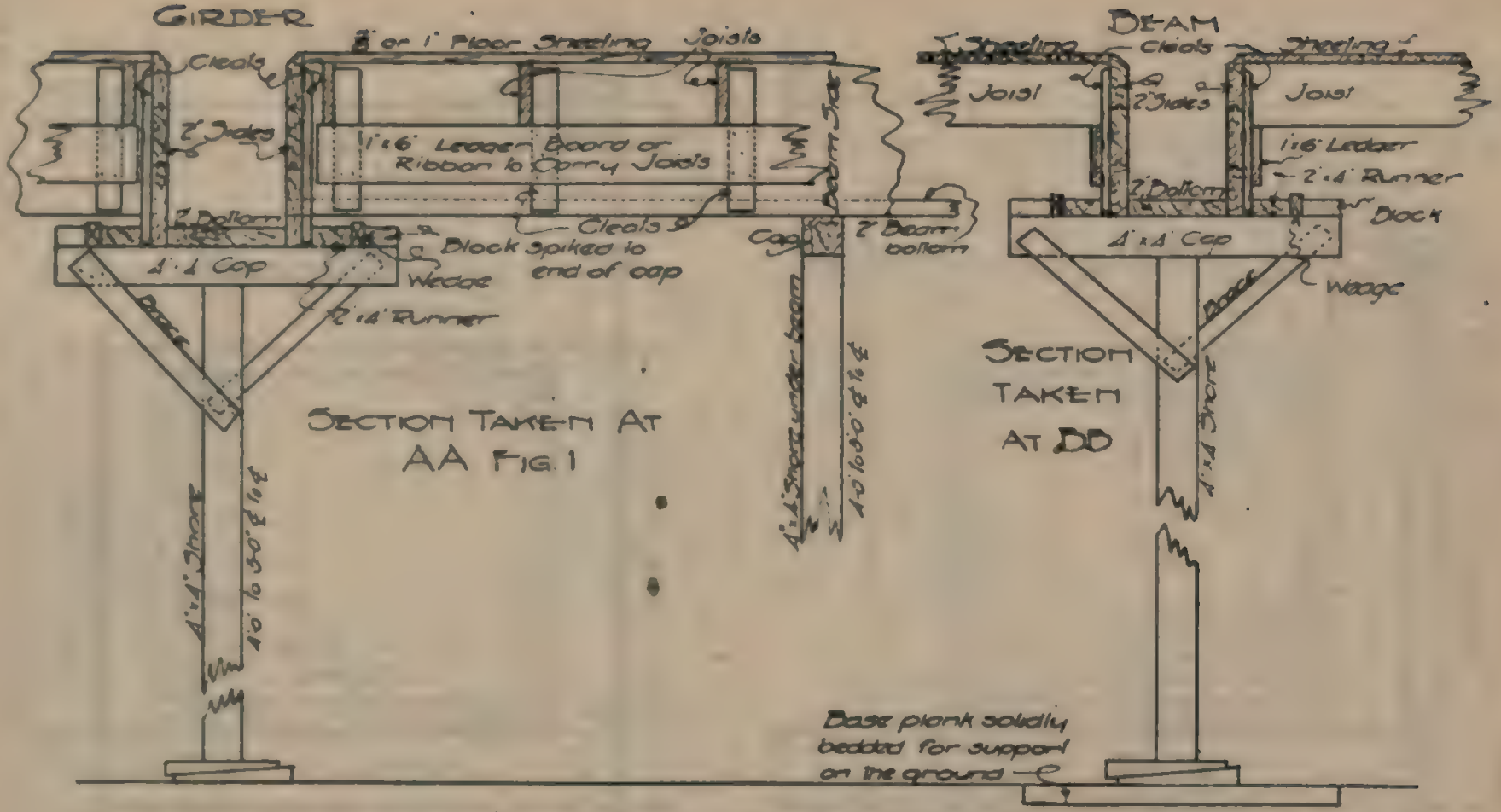


FIG. 3.—SECTIONAL VIEW OF BEAM, GIRDER, AND SLAB FORMS.

hoops of flat steel with bolts to draw up tight.

Every column box must have a hand hole left in the bottom, at least 6 in. high, by which to remove shavings or other refuse which might work its way down into the form. This is imperative.

There are three general types of form construction for reinforced concrete floors. They may be called the Core-Box type, the Panel type and the Loose Piece type. They will be taken up in order.

By the Core-box type is meant the construction in a rigid unit, of the floor sheeting and supporting joists for one panel of a floor together with the sides of the beam and girder boxes confining that panel. It is, when in place, like a shallow box inverted. It is practicable to employ only when there are several typical floors in the building under construction, so that the whole unit for one floor panel may be lowered from underneath the floor where last used, and then raised to some other floor by a derrick, and set in place to be used over again. To use this type of construction makes necessary a very decided chamfer in the sides of the beams or girders. Otherwise the panel could not be removed without great difficulty and probable damage to the lumber owing to the well known wedging action of the concrete. The beam and girder bottoms are loose, and in this instance could be placed either before or after the core forms are in place and lined up. Aside from the suggestion that the joists ought to run the short way of the panel, that is, between the beams, and the sheeting the long way (to save cutting as much as possible), the economical construction of one of these units ought to present no great problem. The sheeting and beam sides could well be made of 7/8-in. matched stuff, and the joists as hereafter mentioned.

The Panel and Loose Piece types of floor form work differ only in that the former contemplates the building of the floor sheeting into a rigid panel, sometimes

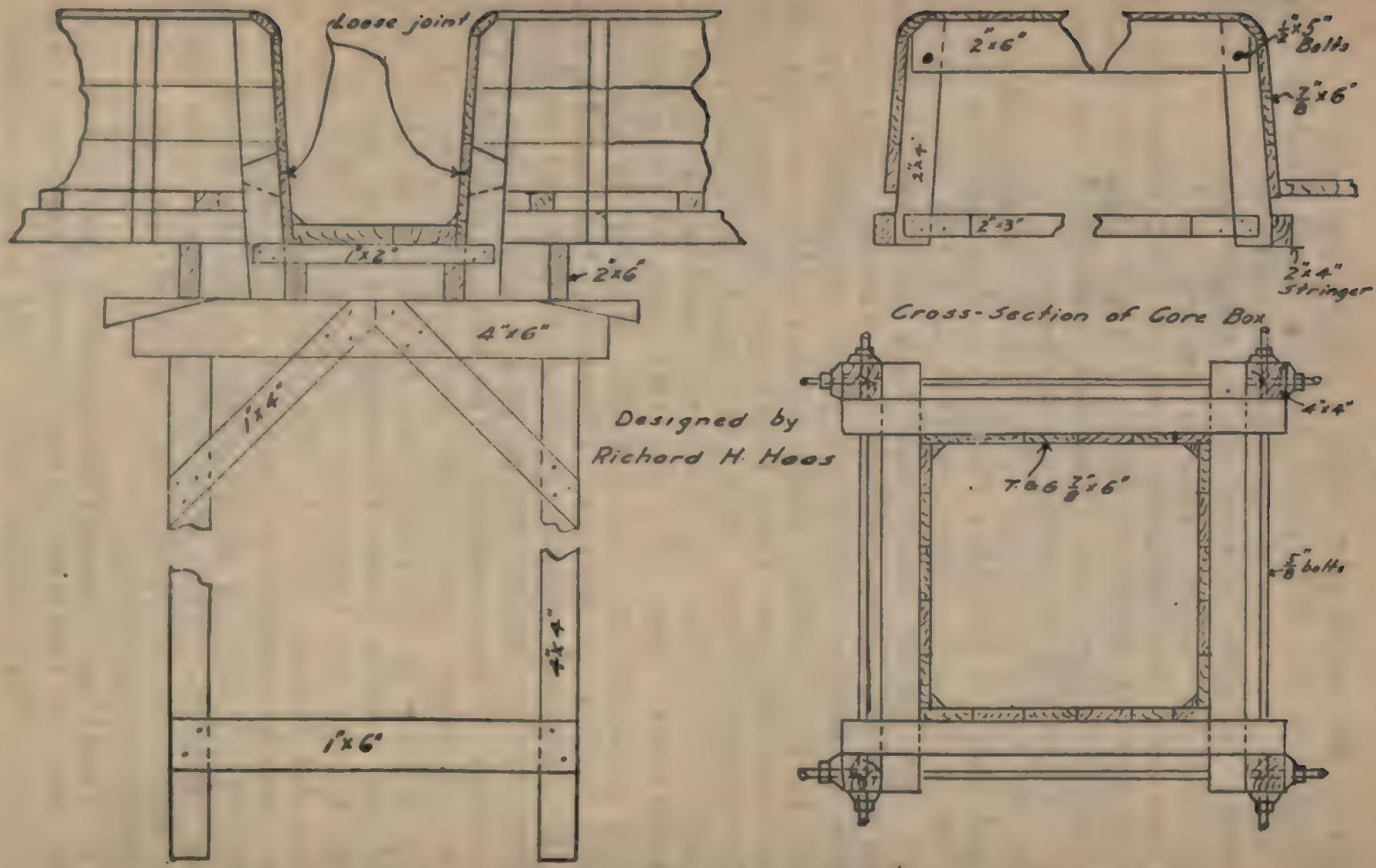
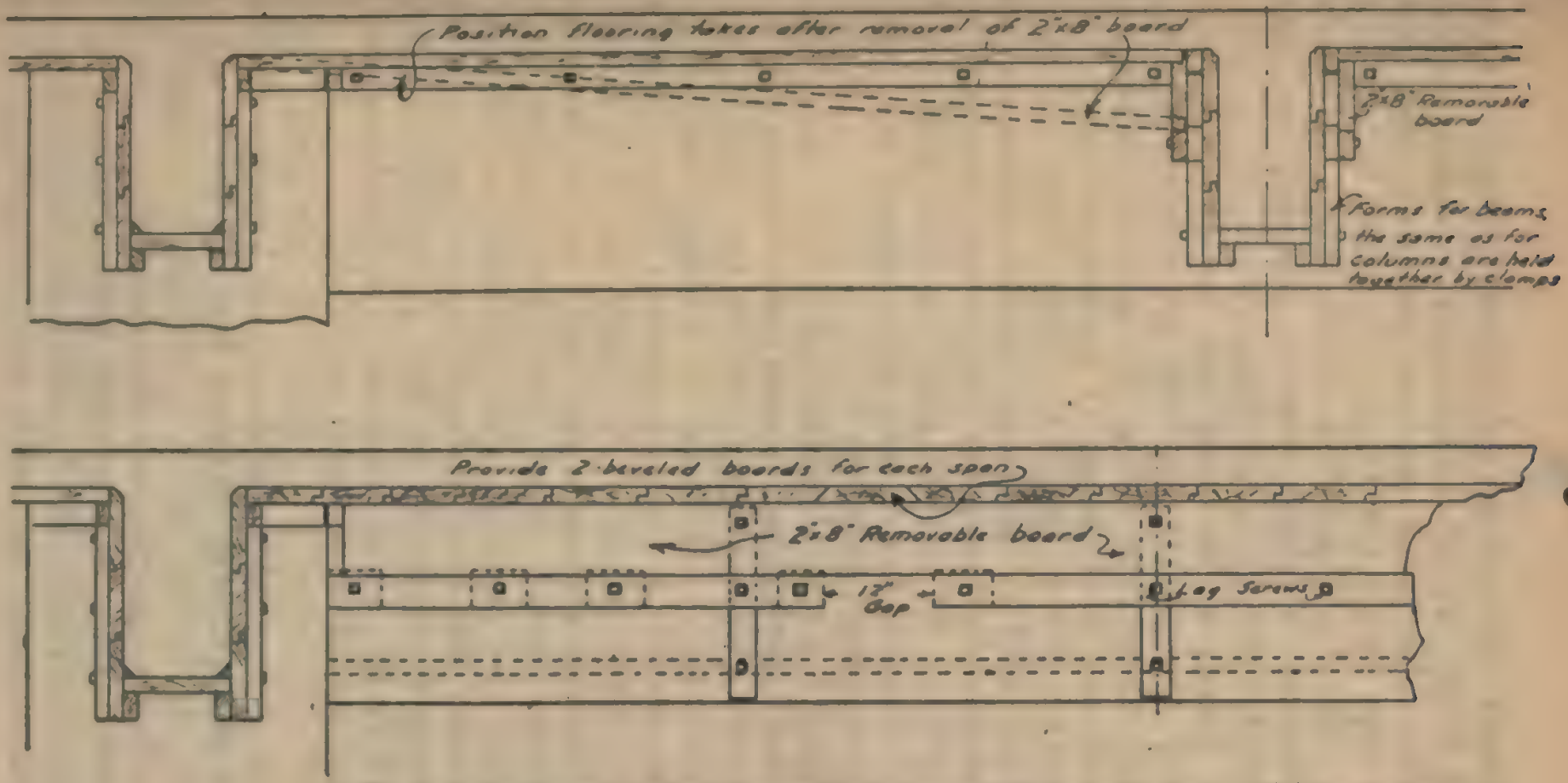


FIG. 4.—CORE-BOX TYPE OF FLOOR CENTERING. SPECIAL DESIGNS OF SUPPORTS AND OF COLUMN FORMS.


Position flooring takes after removal of 2"x8" board
2"x8" Removable board
Forms for beams the same as for columns are held together by clamps
Provide 2 beveled boards for each span
2"x8" Removable board
12" Gap
Lag Screws

The beveled board is first removed (after removable board is down) it being taken down through gap. After one board is removed the rest of the flooring is easily taken down. After the flooring is all removed and the clamps taken down, the wedges "W" as shown are pulled down and we are then able to spread apart the sides of the beam form and take them down.

FIG. 5.—ONE DESIGN OF PANEL TYPE OF FLOOR CENTERING. SHEETING PARALLEL WITH THE GIRDERS.

two half panels, the pieces of sheeting being fastened together by cleats nailed underneath or by nailing the joists direct. The beam and girder sides are not a part of the unit as in the Core-Box type, but are separate units. In the third type no nailing or fastening of floor sheeting is done, except possibly to "tack" down a loose corner or a patching piece.

The loose pieces of sheeting and the loose joists are easy to wreck and hoist, but will present no saving in labor over the panel type when the latter is intelligently done and will not give as good a class of work. The floor strips are never fitted together twice alike and they warp and split to an unjustifiable extent, at least with any but the best grades of lumber, or with thin unmatched stuff. By using good lumber and having it either matched, or better yet, ship-lapped, the quality of the work is much improved.

Now as to the actual building of forms for a floor. The beams and girders of a reinforced concrete floor are really great ribs projectig below the slab forming the floor (or roof). A beam or girder, then, has to have a form made, a box or center (the words are synonymous), built of separate parts to be erected in place to receive the concrete and retain it till thoroughly set. These parts must be light enough to be handled easily and rapidly, rigid enough to withstand the great strains due to the dead load of wet concrete and also preserve perfectly to line the surfaces of the concrete, and at the same time must come down easily, with the least possible damage and delay.

First of all, if there are girders in the floor, which carry beams, the girder bottoms are made of 2-in. lumber with at least one surfaced side which is next to the concrete. It is cut so as to extend not merely to the outside of the column box, but actually to the face of the column. Then the column side, which is to be wrecked first, will not bind. Perhaps the bottom is so long that it must be made of two pieces. Then

simply have a shore directly under the joint. The shores ordinarily are made of 4 x 4-in. or two 2 x 4-in. pieces spiked. They are cut just long enough to leave room for a horizontal cap 4 x 4-in. on top, and wedges underneath them. The 4 x 4-in. cap is long enough to extend a few inches out clear of the girder form to brace to, either above to the girder side or below to the shore. Shore and cap are fastened together by light toe nailing and by two little braces of scrap lumber nailed on, one either way. Of course this is all done on the ground in advance of erection. Shores are generally spaced say 4 or 5 ft. on centers. The girder sides are made up in several ways; 2-in. lumber is more often used than any other, but 1½-in., matched or plain, ⅞-in., and even ½-in. stuff in short vertical pieces are used. The heavier lumber is more usual. To use any other kind is but to adapt the very same principles. The sides are cut with the grain horizontal, and are made wide enough to extend from the under side of the concrete slab usually, to the under side of the girder bottom. The lumber should be ordered carefully in such widths, 8-in., 10-in., 12-in., etc., that, if more than one piece is necessary to get the necessary width, there shall be the least possible ripping. When beams frame into the girder, the girder side must be notched the exact size of the concrete beam. If there is more than one piece in the side, fasten them together with cleats nailed on just strongly enough to make a good job. The girder side is cut to extend to the outside of the column box, or it may be, to a brick wall.

Now when the girder bottom has been put in position and centered, it rests on the horizontal caps on the shores. Then the girder sides being lowered to place in a vertical position their lower edges being flush with the lower face of the bottom, they too, will bear on the caps. To prevent them from spreading when the concrete is run in, you can do one of two things—

drive in plenty of spikes *part way in,* through the side into the bottom, the spikes to be drawn with a special bar with a claw; or, better yet, lay down beside the girder side a 2 x 4-in. Wedge this up tight and so wedge the side up to the bottom tight by wedges bearing against blocks spiked onto the top surface of the cap at the ends. Brace the sides to plumb position, at least temporarily, by short inclined braces tacked to the caps.

What has been said thus far about girder forms, applies almost word for word to beam forms. Some of the beams may or may not frame directly into columns as well as into girders, and they may or may not be as deep as the girders. It must be borne in mind simply that the shores and bottoms have to stay in place for a longer or shorter period, but the rest of the centering, the beam and girder sides, the joists and floor sheeting, have to come down within a comparatively short time. So cut beam bottoms like girder bottoms to extend to the surface of the concrete into which the beam frames. Then there will be no lumber "behind it," that is, between the end of the bottom and the hardened concrete, which can bind when they are trying to loosen it to take down.

Shores of course are made up the same as for girders, varying possibly in length when the beam is not so deep as the girder.

Beam sides in general are made up like the girder sides, but will not have to be notched for any other member framing into them. But the beam sides will have to carry the joists for the floor sheeting. So a ribbon or ledger board for a joist bearer is nailed along the sides outside the cleats. 1 x 6-in. is suitable. It is put on at such a distance below the top edge of the side as to bring the sheeting up to the right level. However, it sometimes happens with shallow beams that there are no cleats on the beam sides, since they are of one piece of lumber only. It is well, then, to

turn the wedging piece, referred to before, up on edge and use this to bear the joists. The latter sometimes have to be notched to bring the sheeting low enough.

In setting up beam and girder sides use spreaders at the top made from waste strips cut as long as the beam is wide to keep the top edges of the beam sides the right distance apart. If a thin strip a little longer at each end than the spreader be nailed to it, it will keep the spreader from falling down into the box and

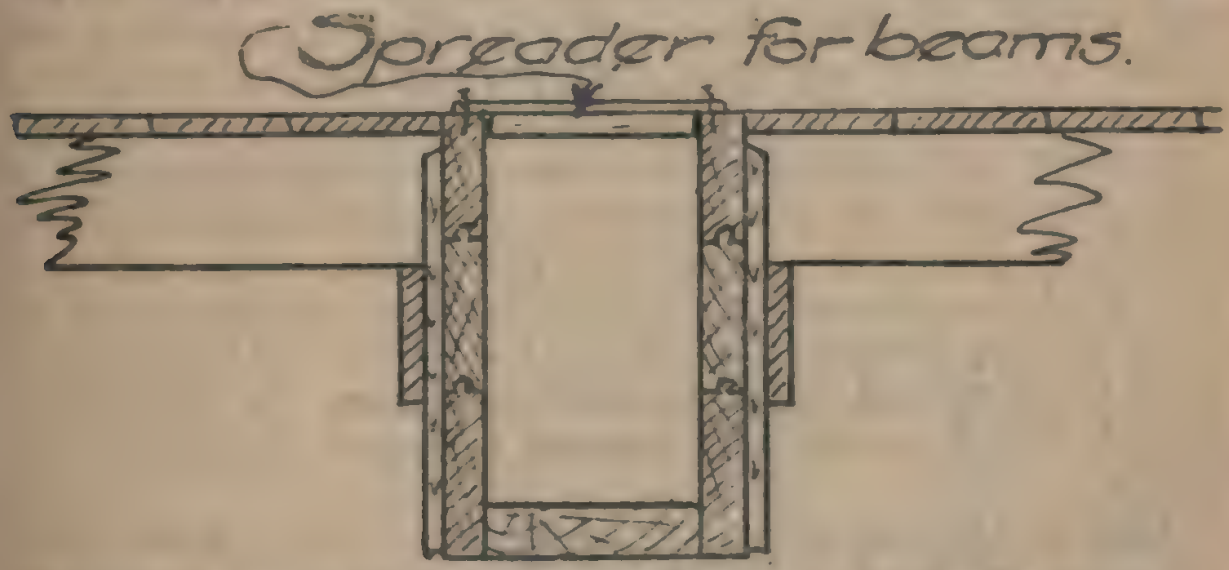


FIG. 6.—SPREADERS USED TO SEPARATE BEAM AND GIRDER SIDES.

may also serve to prevent the sides from spreading, by tacking with a small nail through each end. Keep them in place as long as possible. If taken out while placing steel put back again, and keep in place till absolutely necessary to remove them while concreting.

Various kinds of lumber are used for joists as well as for sheeting. Joists are made of 2 x 4, 2 x 6 and 1⅛ x 8. Conditions determine the size and spacing center to center. Assuming a moderate span between the beams of say 5 to 7 or 8 feet and a good firm decking of ⅞-in. or 1-in. matched or ship-lapped you might use say 2 x 4 at 14-in. to 16-in. center to center, or 2 x 6 or 1⅛ x 8 at 18 in. or 20-in. center to center. This of course implies only moderate loads, i. e., a

slab of 4-in. to 6-in. to be supported on the decking. There are so many conditions that it is impossible to give any hard and fast rules about putting in joists. It is a matter of judgment and experience. The joists must not be spaced too far apart or the decking will spring, and the joists themselves will deflect unduly. On the other hand with big spans, which mean long joists, it is often expedient to put a stringer, 4 x 4 say, under the centers of the joists and shore it up to take the strain off the joists. This will save spacing the joists too close together and prevent too great a load being carried to the beam sides and shores. As a rule the joists are placed without any nailing whatever; at any rate none at the bottom. In wrecking the floor, knock in the bottom till the joist falls over, when it can be taken down at once and out of the way. This may not be practicable with 2 x 4 joists. These might well be mounted on little wedges resting on the ledger board, which could be loosened to knock the joists out again.

Lastly the sheeting or decking. Like joists, the question of kind of lumber is determined by judgment and experience. In fact that is true of all centering. Probably 1-in. stuff surfaced is used oftener than any other. If you have to present a first class ceiling surface use matched or ship-lapped lumber. No mortar can run out of the mass of concrete to leave unsightly crevasses with the aggregate showing.

As mentioned before, if the floors are typical and the sheeting is to be used over and over, it is common to form the sheeting in a solid panel or in half panels of moderate size. The strips are simply fastened together by nailing cleats underneath just sufficient to hold all, with moderate usage, true and accurate to line.

We said under beam and girder sides that they should extend to the under side of the slab. This means that the sheeting would be fitted up flush against that part of the beam forms and would serve to brace

it in against the pressure of concrete in the beam. This also enables one to provide for a beveled edge on the centering along the beam by beveling the edge of the beam side. Another method of procedure is to form the sheeting the full width and length of the floor panel, letting the beam forms come up under the sheeting. With heavier lumber any required bevel can be taken care of on the sheeting. Then in wrecking there will be sufficient "hang" to the sheeting, whether loose strips or panel type, so that it will stay in place till everything else is down and out of the way.

It frequently happens that openings have to be provided for in floors or flat roofs for skylights, or ventilator ducts or for other purposes. Unless these openings are very large, it will not pay to cut a hole in the floor centering. It is much more economical to sheet over the whole floor and then build a light frame as deep as the thickness of the slab and of the same size as the opening. Tack this lightly in place on the sheeting. It will serve to stop off the concrete and leave the desired opening after which it may be easily removed when the centering is wrecked.

A few words about erecting. The column boxes are first. Get them lined up and plumbed and then brace temporarily but strongly. Do not put on the collars the first thing, at least not more than are absolutely necessary. It may be important to remove a side to get at the steel later. The girder and beam bottoms go up next, each supported on as few shores as possible for the time being. Center them up at about the right level and brace. Then put a camber or crown to each one, determined by experience, perhaps 3/8-in., perhaps 5/8-in., to allow for settling. The camber refers more particularly to the center. Have the shores rest on substantial wedges. By carefully driving these wedges you can get your level quickly and accurately. In the case of a first floor whose shores are supported on the ground, provide short base planks for foundations for

the shores, and see that they are well bedded. When centering up in freezing weather on a first floor, or when braces go into the ground, take every precaution against a thaw softening up the ground and throwing the work out of line. Place the remaining shores and brace all well. For very long shores put in such bracing as to secure them against possible buckling. Next place the beam and girder sides and plumb, using the spreaders referred to. Make all tight and follow with the joists and sheeting.

In placing shores for any of the upper stories, be sure that they come over the beams below. This is imperative.

Careless mechanics in placing joists will cut them too long, and wedge the beam boxes in at the top. This is one of the reasons calling for the use of spreaders as noted previously.

Teach your carpenters never to do any sawing over a finished beam box. The sawdust and chips will all have to be cleaned out again, and it is unnecessary carelessness.

Sometimes with very deep girders, it may be necessary to secure the sides against bulging at the half depth from the pressure. A good way is to use No. 9 iron wire. Drill two small holes in each girder side opposite each other and pass the ends of a suitable piece of wire through. Twist the ends together on the outside securely, then if necessary put a small stick or rod between the two strands inside the form and twist till the sides are brought together tight up against a spreader of the right length. Of course the wire must bear on some piece or cleat or something in the loops outside the box to distribute the pressure against the girder sides. This wire may be cut very easily to allow removing the sides. This wire is put in after the steel is placed.

Check over forms very carefully before running any concrete. See that all walls, girder and beam sides,

and columns are true, plumb, and thoroughly braced. See that spacing, width and depth are accurate. Never trust too much to memory. Carry blue prints with you in checking up.

It is very poor policy to let any centering stand in a hot sun an hour longer than is necessary. Plan the placing of steel and concrete accordingly.

When wrecking it will be found very convenient to use two tall horses under a floor panel. They may be built of comparatively light stuff and so be portable, and can be designed in a number of ways. The main

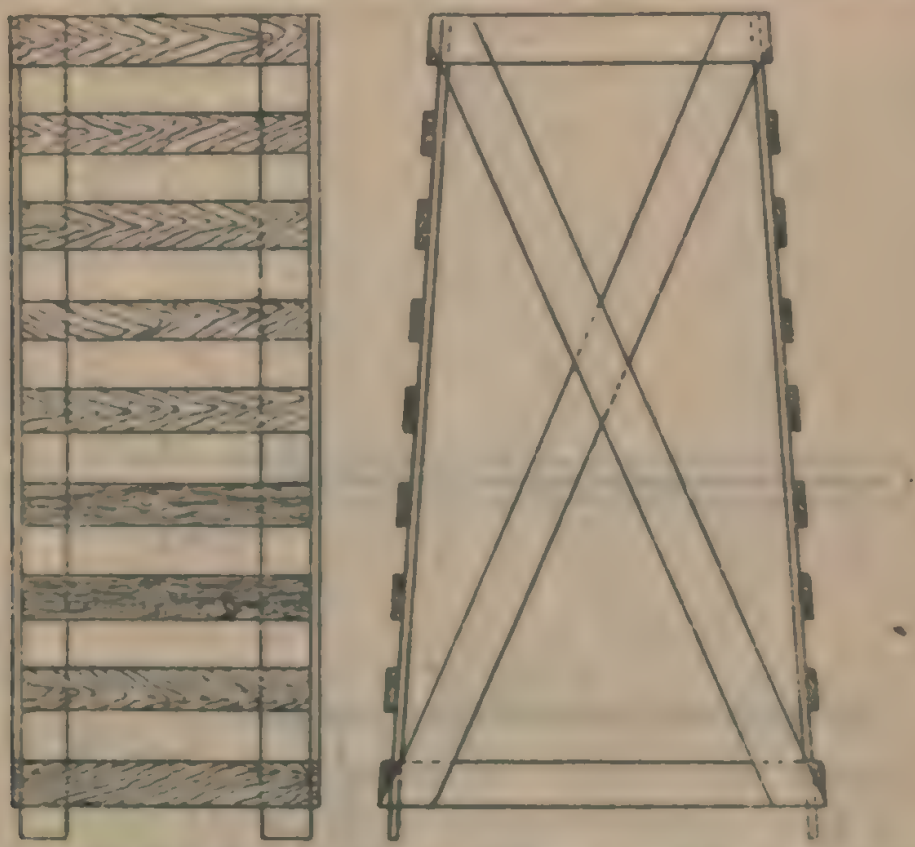


FIG. 7.—SKETCH OF DOUBLE STEP-LADDER OR HORSE USED IN REMOVING CENTERING.

thing is to combine the idea of a ladder or possibly two ladders facing each other on each horse, with that of a horse onto which to lower the longer stuff as it comes down, then lower to the floor and remove.

Never let any foreman remove centering without instructions.

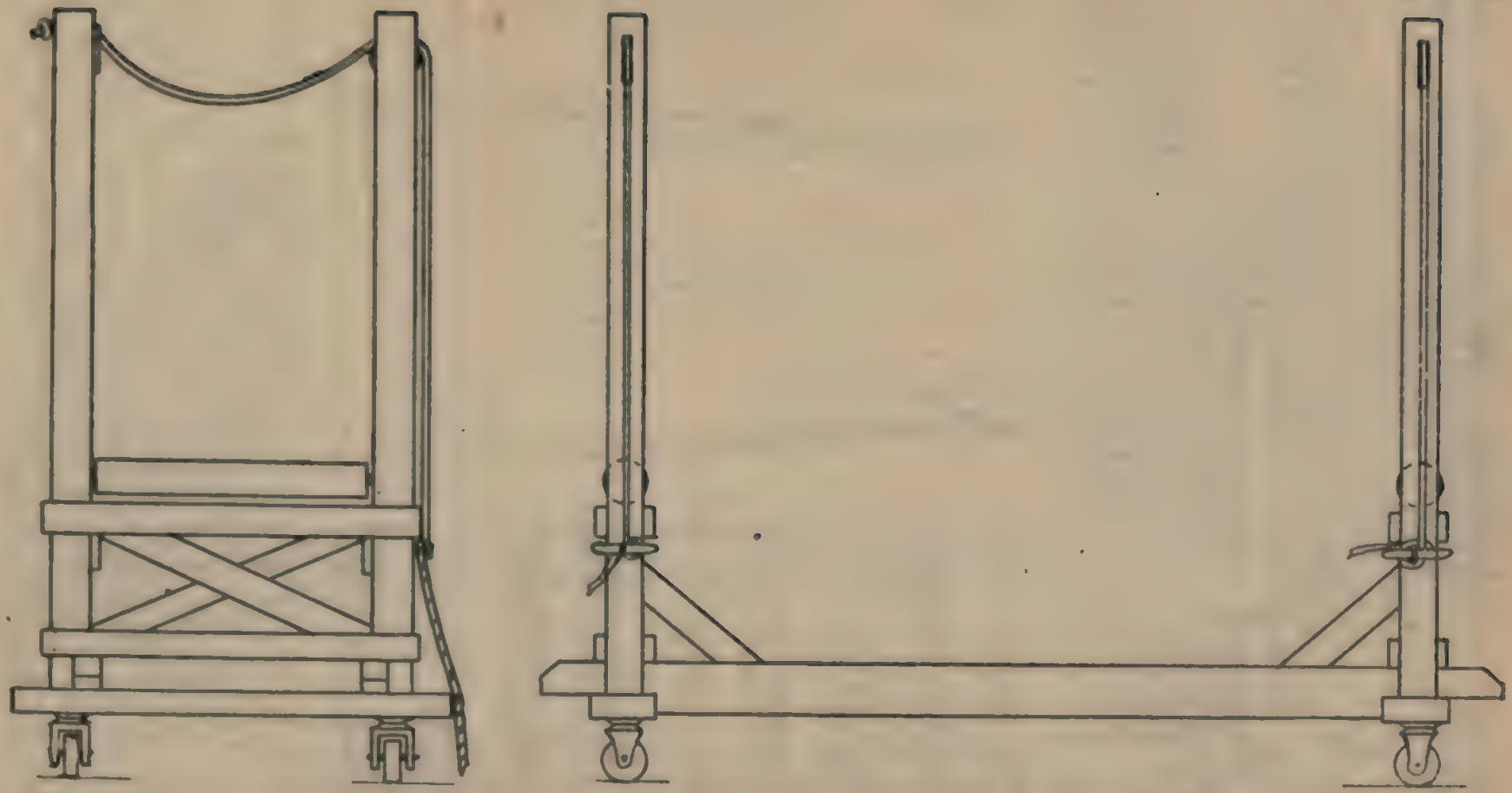


FIG. 9.—TRUCK FOR HANDLING FLOOR FORMS AS THEY ARE WRECKED.

Post notices to prevent loading of green floors.

Never under any circumstances remove more than a very few shores until the final time for removal. Taking out of shores while centering new floors, and then "posting" the floors is bad practice and must not be tolerated. Study your design so that this practice is not necessary.

Avoid all shock and jar to new concrete. Never allow pieces of lumber of any size to fall or to be thrown down upon a floor. The effect of the impact of a falling body is very severe and may be very costly in its results.

FOOTINGS.

Concrete footings for columns and piers are built either in step form or with sloping of battered faces. It is a very simple matter to build forms for step footings. Simply make a strong form for one layer at a time. Run that layer and when it has sufficiently set put on the form for the next and so on. The form must be capable of being taken apart easily in order to remove it from around the concrete. This method is for layers 12 in. thick and over.

Footings with battered faces are a different proposition. If the footing is very shallow compared with its size, build a box the size and depth of the outer square faces. Then fit perhaps one board on all four sides of the box pitching backwards and upwards toward the center, its outer edge flush with the edge of the box. This will give the slope of the top faces, and prevent the concrete running off the form. Fill in the whole form with concrete of fair consistency to the height required, simply sloping off the concrete with a shovel or float. This assumes of course that the top surfaces are very flat. The concrete will not run to any appreciable extent if just stiff enough, especially the last few barrow loads.

However, if the faces were steep enough to make a complete form necessary clear to the top of the foot-

ing, it is possible that the form will have a tendency to "float," due to the lifting action of the wet concrete. We get around that with the shallow footing by doing without a complete form on top. But now such a form is necessary. Probably the best way is as follows: make the footing virtually a step footing by using a series of frames with vertical sides only 5 in. or 6 in. high, made to give approximately the batter required. Put down one frame and fill. While the concrete is still somewhat soft, put down the next smaller frame and fill, and so on till the height is attained. After the frames are removed if the sloping surface is insisted upon fill the steps with mortar and trowel smooth.

WALLS.

Forms for retaining walls, curtain walls, etc., will be discussed but briefly. In general it may be said there are two modes of procedure for walls of any magnitude. First, on large buildings, walls may be carried up in comparatively shallow horizontal layers uniformly around the work. Second, complete forms the full height of the wall may be built in limited sections and they are poured full at one time. The first method gives horizontal joints between different sections of concrete, the second gives vertical or irregular joints. The first method means more runways but the

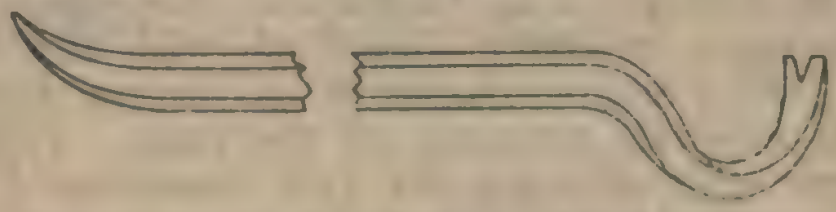


FIG. 8.—SKETCH OF USEFUL BAR FOR SETTING AS WELL AS WRECKING FORMS.

centering is usually much lighter because the pressure of concrete due to a thin layer is inconsiderable when compared to that due to the head in a deep form. The centering is often built in panels which are raised and used over and over.

On wall centering, be very careful to use boards of the same thickness. Unequal boards give a very disagreeable unworkmanlike surface.

A hand-hole should be left in wall centering at various points to allow an examination of the concrete before pulling the centering.

In some cases the forms may be braced in against spreaders to keep them lined up, but in place of braces it is much more usual to employ wire ties or bolts passing through the wall to hold the wall forms together. This means that the bolts have to be driven out again or cut off and any wiring has to be cut in order to remove the centerings. Instead of wire, band steel may be used. It is passed through the cracks in the boards and nailed around a cleat or stud. Use ½-in. x No. 18 gauge, soft steel for ordinary work. This is about equivalent to 2 strands of No. 9 annealed wire.

Wall ties, either bolts, wire or steel, should be put through at right angles, or square with the wall. The centering will be "skewed" if this is not watched.

Turning up bolts with a monkey wrench is slow work. Use a ratchet wrench or hand nuts.

Wires will cut through wood with the weight of the wet concrete on wall forms. Therefore to protect a stud put a piece of scrap lumber under the wire. In twisting up (using No. 9 annealed) do not twist too tightly, or you will burn and kill the wire.

Bracing for wall forms is poor practice if the walls can be reached from both sides to use wire; straps or bolts. If bracing is used, put no trust in nails, but use positive shoulder action at all points, with nailing blocks or otherwise. Never brace a shore back into the ground without a base block under it.

STAIRS.

The centering for reinforced concrete stairs is a simple matter. The soffit or under side of the rake

of the stair is usually a smooth inclined surface. It is sheeted up like a floor, the sheeting resting on stringers which must be very strongly supported and braced to prevent any possible displacement. Now to form the treads and risers, a horse is made, underneath and against which the concrete is to be flowed on top of the sheeting, which will give the required form of the steps. This horse can be made in several ways, the essential features being that there are suitable pieces for stringers to give rigidity, and then attached to these stringers are 1-in. pieces the exact size of and held in the exact position of the risers on the stair run. In other words, the horse is so built that if it could be lowered into position on top of the stair when finished, its contour would exactly conform to the contour of the treads and risers. But while boards are necessary to form the risers, none are used for the treads, except possibly a few at the very bottom to keep the wet concrete from flowing out over the riser boards. Be sure that this horse is not only supported well, but is braced strongly from above to prevent the slightest tendency to lift or float. If the stair run is to have a smooth top surface without steps, no horse will be necessary, usually, or any top form, except for a short distance up from the bottom. The concrete if made of the right consistency, rather stiff, will not flow to any extent when it is tamped slightly in place.

OILING FORMS.

This is done to prevent concrete adhering to forms, warping, etc.; to preserve the lumber, and secure a better surface on the finished concrete. Soft soap, 1 part of soap to 4 parts hot water, is good.

The oils or water resisting preparations commonly used are, crude oil (petroleum), paraffine (refined petroleum), asphaltum paint or varnish.

These must be thinned to the proper consistency as occasion demands and applied to forms, either by dip-

ping or painting the lumber or painting the forms after they are set. Be very careful in this last not to allow any of the steel to come in contact with these oils.

Do not use any preparation when the wall is to be plastered, as an oil would prevent plaster adhesion. Use unsurfaced lumber in this case when practicable.

TABLE

PRESSURE OF FRESH "SOUPY" CONCRETE

Depth in ft.	Pressure on vertical strip 1 ft. wide	Pressure on 1 sq. ft.	Depth in ft.	Pressure on vertical strip 1 ft. wide	Pressure on 1 sq. ft.	Depth in ft.	Pressure on vertical strip 1 ft. wide	Pressure on 1 sq. ft.
1	40	80	9	3,240	720	17	11,560	1,360
2	160	160	10	4,000	800	18	12,960	1,440
3	360	240	11	4,840	880	19	14,440	1,520
4	640	320	12	5,760	960	20	16,000	1,600
5	1,000	400	13	6,760	1,040	21	17,640	1,680
6	1,440	480	14	7,840	1,120	22	19,360	1,760
7	1,960	560	15	9,000	1,200	23	21,160	1,840
8	2,560	640	16	14,240	1,280	24	23,044	1,920

TABLE

THICKNESS of HORIZONTAL BOARDS for FORMS. VERTICAL STUDDING 2×4 IN.

Thickness of Boards	Studding Intervals 12"	18"	24"
	Height of Forms		
Inches	Feet		
1	8½	3	2½
1¼	14	6½	4
1½	21	10½	5½
1¾	28	12½	9
2	39	18½	12

It is assumed all boards are ⅛ in less than here given

Studding is assumed to be sufficiently braced or tied

As heights of form increase use thicker boards at bottom or set studding closer

STEEL FABRICATION AND PLACING.

Shipment of Steel.—Steel is usually shipped in open freight cars, although flat cars are used for longer lengths. Regular carload and less-carload conditions apply. In hauling steel to work, do not let the material drag on the ground, but use an extra pair of wheels as a trailer.

Receiving Steel on the Works.—Upon receipt, steel should be racked in a workmanlike manner. Make a separate pile for each size and length, and pile the

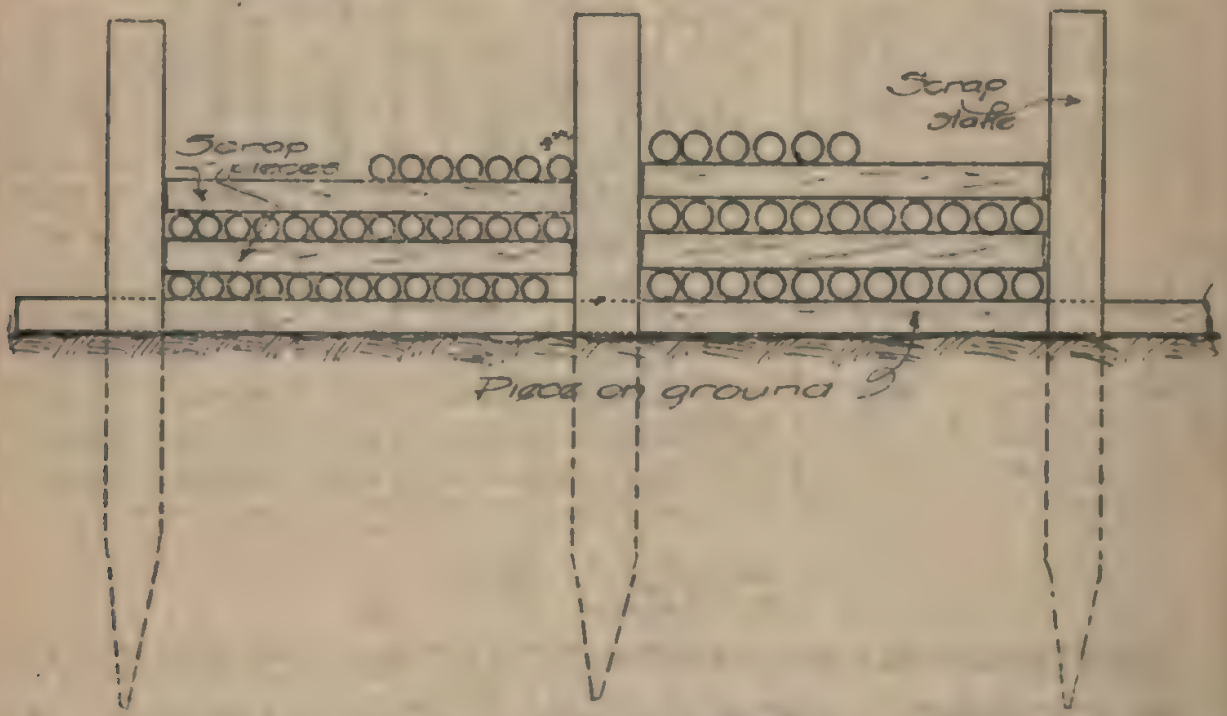
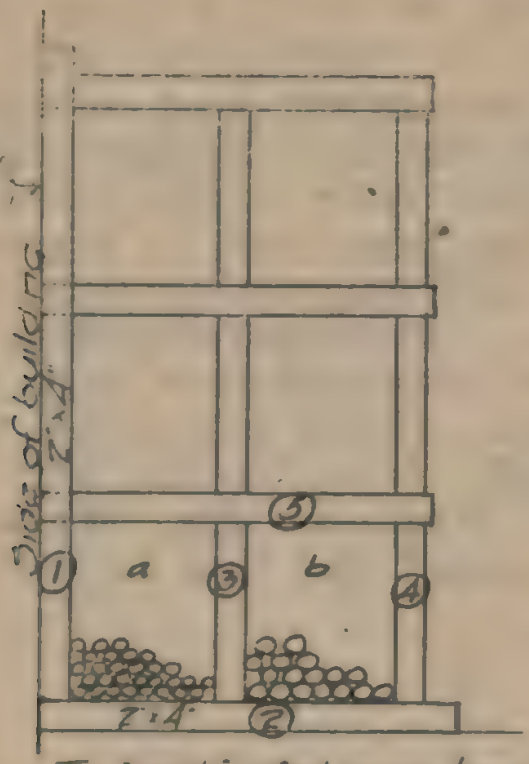


FIG. 10.—RACKING STEEL RODS ON GROUND.

rods 10 wide on the larger sizes and 5 or 10 bundles wide on the smaller stuff. By receiving and stacking steel in this manner, a tally of the material is very easily made and there is also a constant check on the material on hand.

Keeping Track of the Steel.—Steel is ordered to exactly fill the requisition as made out in the engineer's office, and if filled at the mill properly, should come onto the work and be checked up with no difficulty. The office should of course send to the man in charge

of the work a duplicate of the requisition from which the mill order was made. The field should also have a duplicate of the mill order to check back upon receiving steel.



To "rack" steel rods beside a building, put a sill-piece ② on the ground, and an upright against wall ①. Fill space 'a' with rods of same size and length. Rack ③ in place, fill space 'b', rack ④ and ⑤ in place, and so on. Rods are removed by pulling out endwise.

FIG. 11.—RACKING STEEL RODS BESIDE A WALL.

These two steel lists properly checked, may become your stock sheet, and if there is room in the yard to rack the steel in the proper units as noted above, this yard itself, on an ordinary sized construction job, becomes your detailed stock sheet. When it is desired, however, to keep material lists (and on most work this is undoubtedly a precaution which it is well to use in connection with the above method), use plenty

of room in the record book. An ordinary 6¾-in. x 3¾-in. ring side-opening loose-leaf book, has been used with success. Under "S" a separate sheet for each size of steel can be used, skipping one or two lines between entries of length. The main thing to be remembered, in keeping any kind of stock list, is to use plenty of room, use care in classifying, and eliminate every unnecessary entry. The loose-leaf book mentioned above has been used in keeping track of material records and engineering data on two or three jobs at a time. One important thing to remember is to lay out your plan and then keep the entries right up to the minute. This is one of the values of a loose-leaf pocket book. It is "on the job" all the time.

Fabricating Steel on the Work.—This consists mainly in "trussing" the bars to the required shapes.

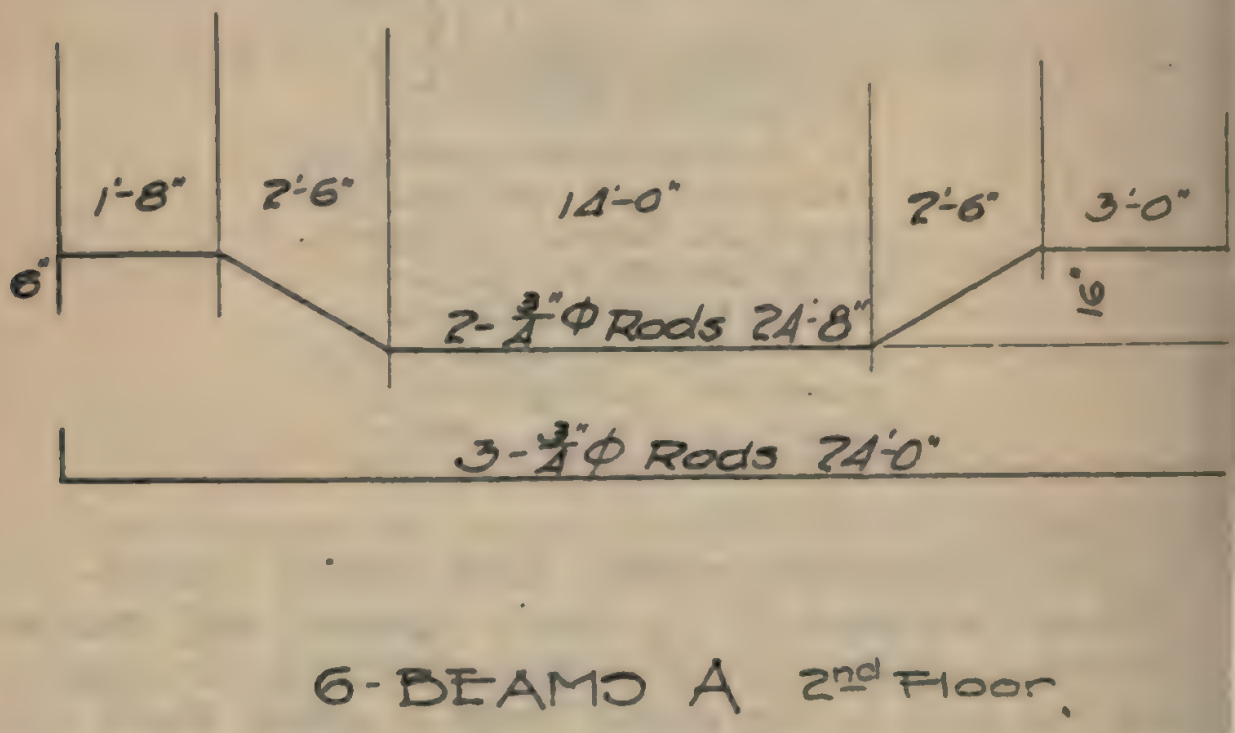


FIG. 12.—DETAIL FOR BENDING STEEL RODS FOR REINFORCED CONCRETE BEAM.

There should be detailed drawings following the line of structural steel, showing the number and dimensions required. See Fig. 12 for typical detail sheet.

Benches for trussing bars can be made in two ways. One is essentially an ordinary work bench of 2 x 12 rough material, so cross braced and staked to the

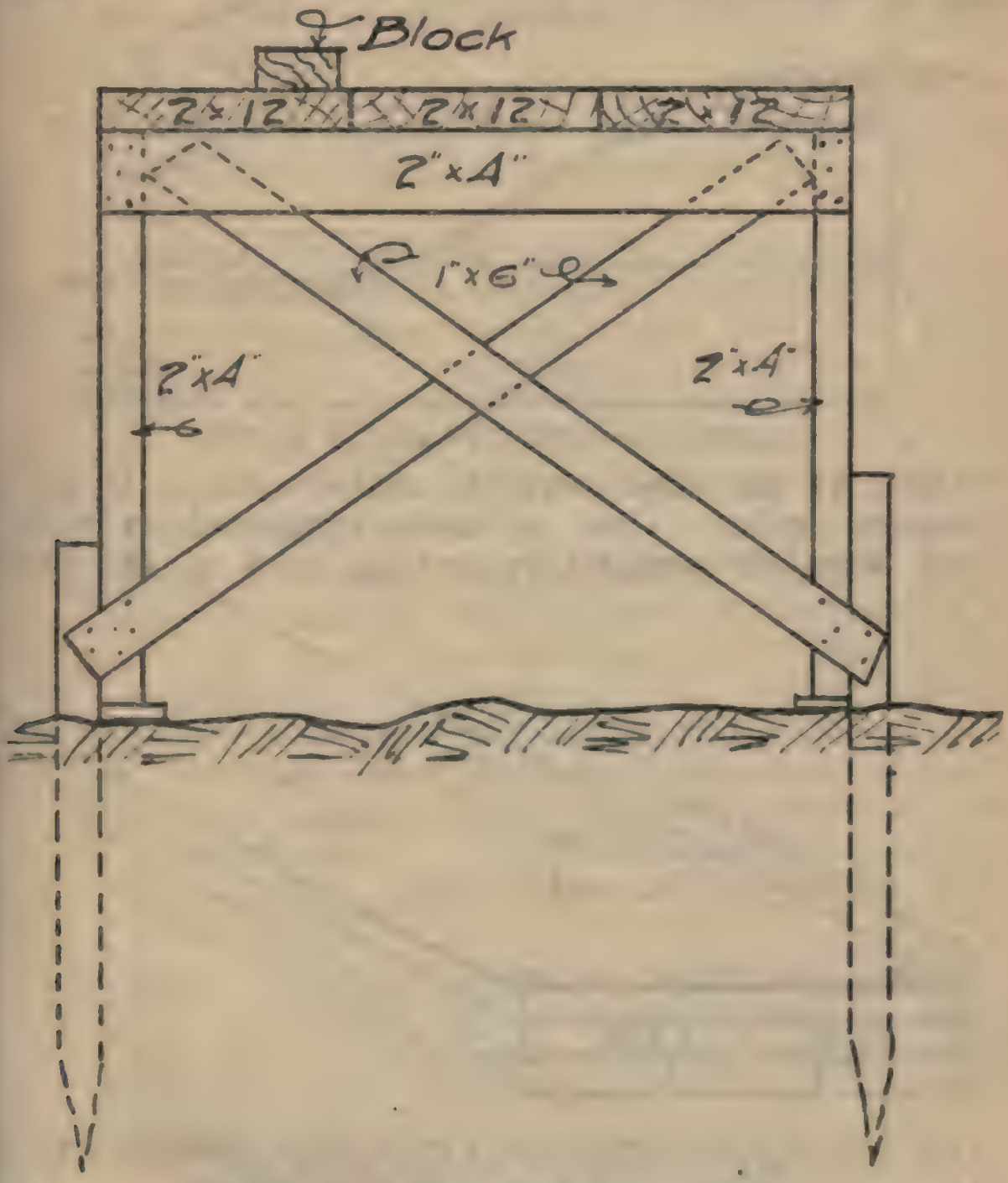


FIG. 13.—END VIEW OF BENCH.

ground as to resist the pull exerted in bending the rods. The templet is secured by nailing blocks of 2 x 4 on top of the bench.

As the steel bars are trussed, the detail sheet should be checked off, and the bars tagged. Ordinary shipping tags can be used for this.

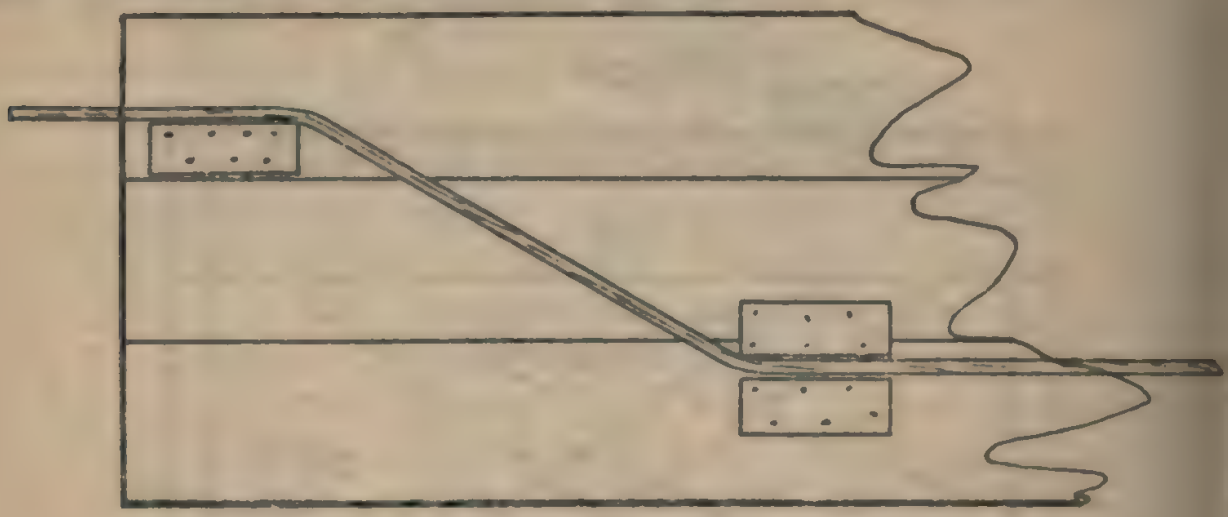


FIG. 14.—PART PLAN OF BENCH.

One of the other ways to make a bench is to use heavier timbers, (8x8 to 12x12 supported on horses) and form the templet by boring holes at the proper

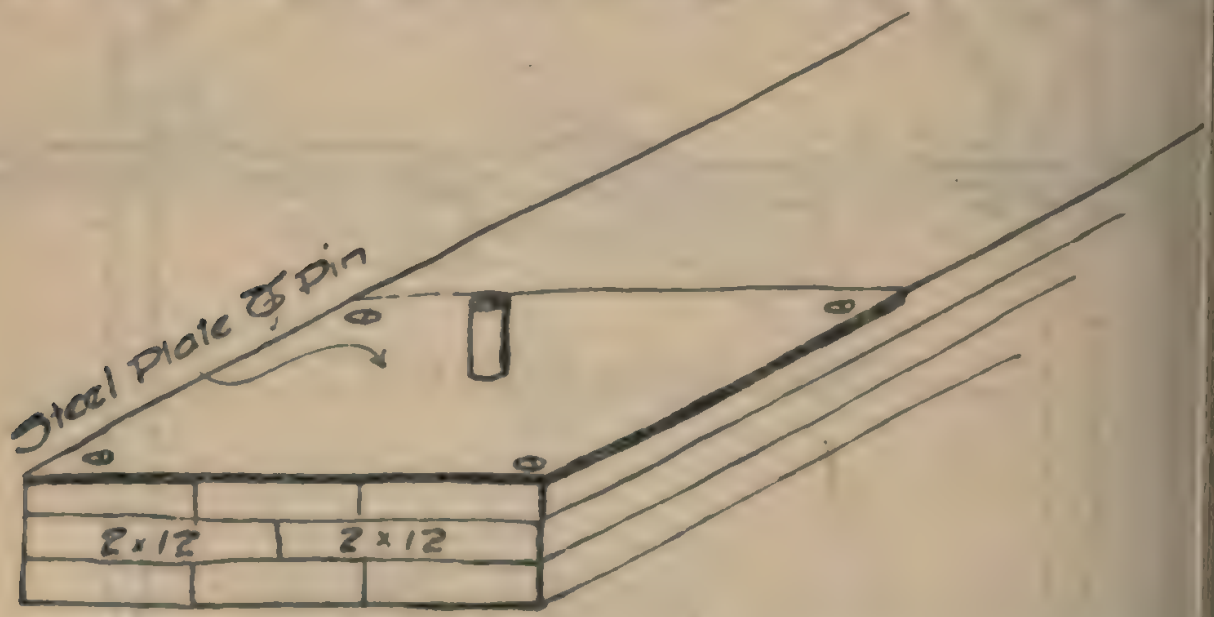


FIG. 15.—USEFUL TYPE OF BENCH FOR BENDING STEEL

places and dropping in vertical steel pins. A heavy bench for bending could also be made from any 2-in material cleated together, and properly supported o horses. Short pieces of 2x6 spiked across the to

solid at the bending point to keep the planks from pulling apart. Drop short steel pins in the holes to form a templet in the same way as in the use of a solid timber bench. Always, if possible, bend all rods of the same pattern at the same time in order to avoid changing pins or blocks.

There are on the market today several simple machines for bending these rods. From construction men who have used both the verdict seems to be in favor of a machine.

Always tag each member for its proper position.

Use a steam pipe with a coupling on the end to make the short turns, when bending cold. The men should be equipped with canvas gloves. Teach the men to pull together on this work. Two men should be able to make all the bends, but use three men on a crew, one at each end of the bench and the third going back and forth to help in bending.

Bending Stirrups.—Bending shear stirrups or U-s can either be done by hand on any of the benches described, or by one of the machines now on the market. For shearing use a compound lever shear, although some construction men use hack saws.

Hot Bending.—Hot bending, sometimes necessary, is not recommended by all engineers, and in some cases is questionable. Use a small portable forge, and support the rods with horses at the proper height while being heated.

Stirrups.—When stirrups are wired or clipped to the main bars, work on this inverted, that is, reverse from the way it goes into the form. Attach stirrups at proper spacing. Make the horses high enough so that the men will not be compelled to stoop over.

WALL REINFORCEMENT.

It is difficult to give any comprehensive discussion of this question without going further into detail than the occasion warrants. The main thing to accomplish,

as in floor reinforcement, is to put the steel in place according to plans, study the situation and save labor cost. But by all means, put that steel in in such a manner and by such means that it *cannot be displaced* in pouring and tamping concrete.

In ordinary monolith wall construction, it is less expensive and more satisfactory to place the steel after one side of the centering is up, using this to work against. Use thorough workmanlike methods to secure the steel in position, and follow the best leads that circumstances present.

It is almost too apparent to require mention that the steel can be maintained in position by fastening to the tie rods or wires as the work progresses. As mentioned under "Field Manufacture of Concrete," care should be used in tamping in wall construction. Especially as the final position of the steel depends to a great extent on the intelligence used in the tamping.

Steel in footings must be taken care of in the best possible way that occasion offers.

POSITION OF THE REINFORCING STEEL.

The vital necessity of adopting positive means to secure an exact position of the steel during the operation of pouring and tamping concrete is not realized by most constructors.

Steel must be at a specified distance from the exterior surface to allow for fireproofing. Steel must be at the required depth from the top of the slab to meet the stresses to resist which it is designed. At this critical point the steel must be held and it behooves the man in the field to watch this point very carefully. There are on the market today a dozen or so "unit" systems which secure this result. It will pay the field man to send for handbooks describing these, and study them, and try as nearly as possible to work toward this end with the means at hand.

The entire question of placing the steel is not so complex as it might seem. The design *must* be understood. The vital importance of having the steel in according to the design *must* be comprehended. Put an intelligent mechanic at it, keep him at it all the time, and check him carefully. Check a section of the floor after the steel is in and before the concrete is placed to see that all the steel is there and in the right position. Then watch the men while the concrete is being poured. That "eternal vigilance is the price of freedom" from mistakes is as true on construction work as anything else.

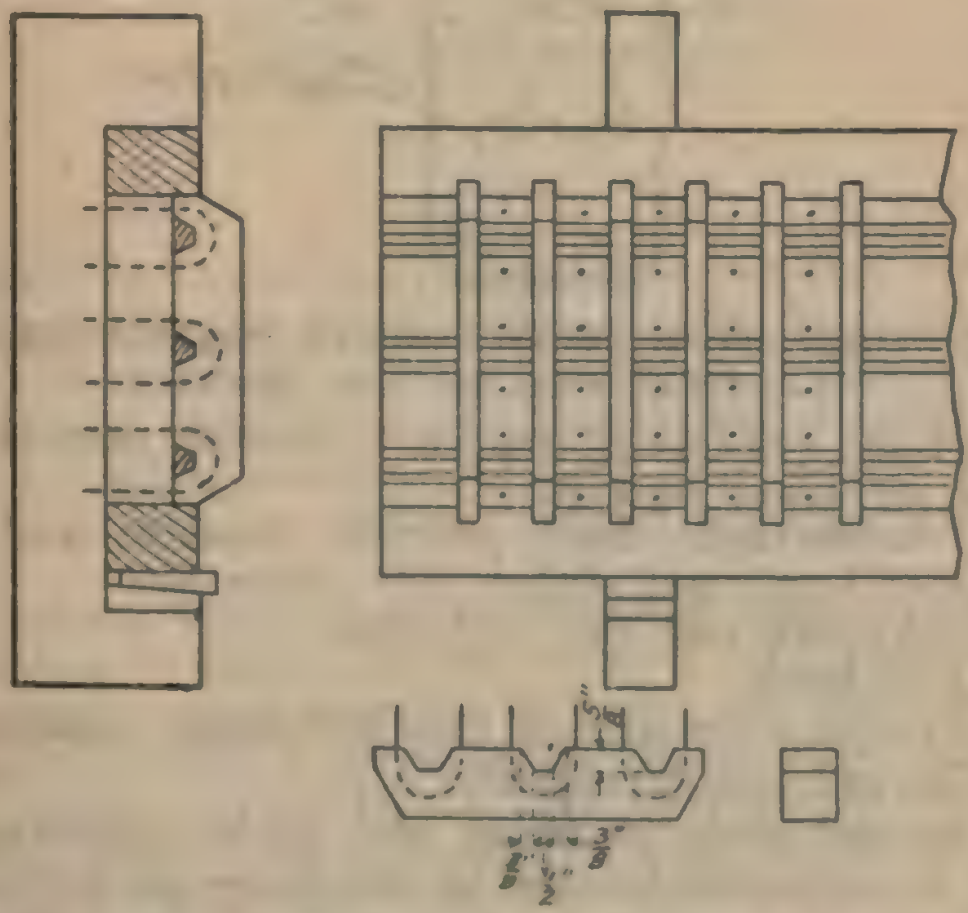


FIG. 16.—MOLD FOR MAKING CONCRETE SADDLES, OR SEPARATORS, FOR BEAM AND GIRDER RODS.

Concrete Spacers.—To secure an exact placement of the beam and girder steel, we recommend a concrete and steel saddle made on the work, as illustrated in

the accompanying sketch.

Openings.—Precautions should be taken to provide extra reinforcement when slabs or beams are weakened by open spaces as noted, Fig. 17. A cantilever

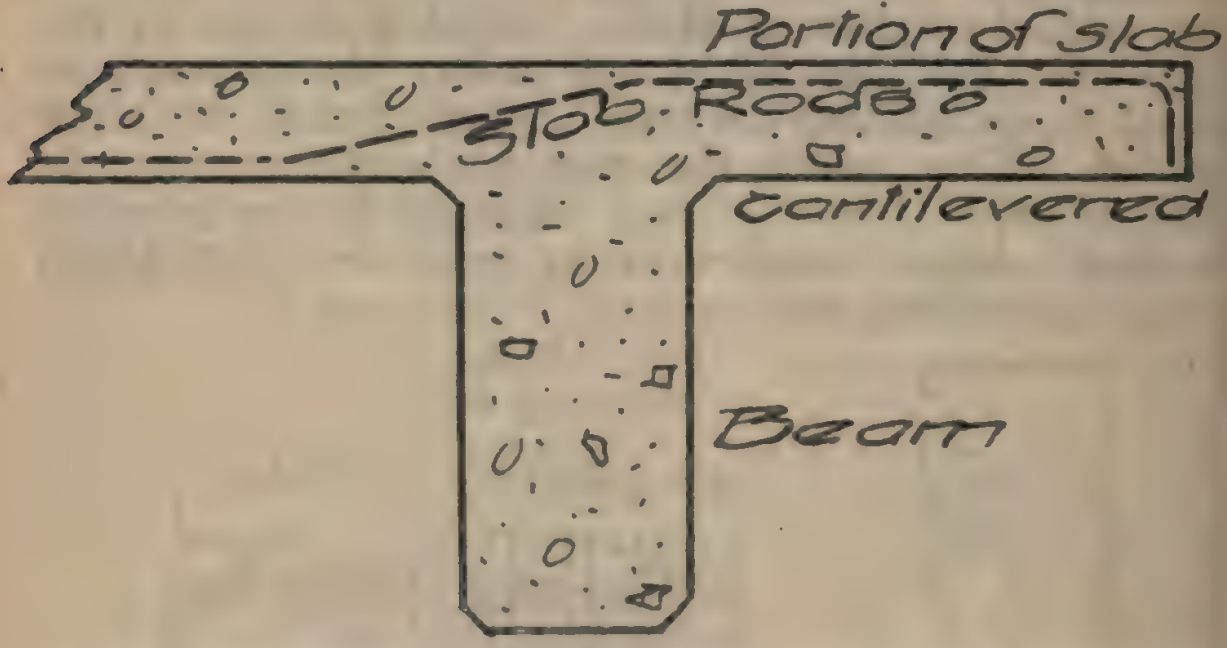


FIG. 17.—POSITION OF STEEL RODS IN PORTION OF SLAB CANTILEVERED BEYOND BEAM.

action of the reinforcing steel is commonly used at elevator or light-well opening.

End Anchorage.—Best practice demands end anchorage of beam and girder rods either by:

(1) Threaded end, nut and plate.
(2) End hook.
(3) Continuation of rod into adjoining member.
(4) Thread and turnbuckles.

All trussed rods in beam and girder construction should be anchored by one of the above methods.

Slab rods are usually made continuous by lapping.

Clean Steel.—Steel must be free from grease, loam or any foreign matter. Excessive rust or mill scale should be removed with wire brushes.

Columns.—Column reinforcement should be concentric with the column. Use positive means to secure

this. Note the method of running concrete columns as described on page 57.

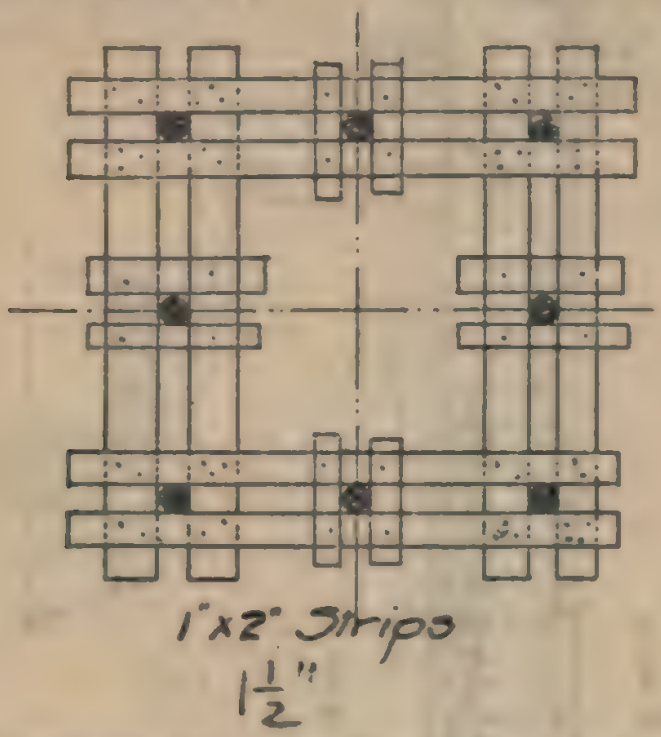


FIG. 19.—TEMPLET FOR SPACING COLUMN RODS.

Avoid Metal Rests.—Unless absolutely necessary, metal should not rest on the forms. This condition is liable to develop a rust spot in the future. Metal is too good a conductor of heat to be placed between the lower surface of the concrete and the reinforcing rods.

Marking Centering for Placing Steel.—When the centering is ready for the steel, it is a good idea to have your steel foreman go over the floor with the blue-prints and a piece of crayon or keel, and letter the beams and girders to correspond with the plans, in big plain letters on the decking beside the beams and also specify the rods required, like this:

BEAMA.
2—¾-in. Twisted—Bent.
2—⅞-in. Twisted—Straight.

It is also an easy matter to lay down a pole or a rule and mark the rod spacing. "Spot the rods" as it

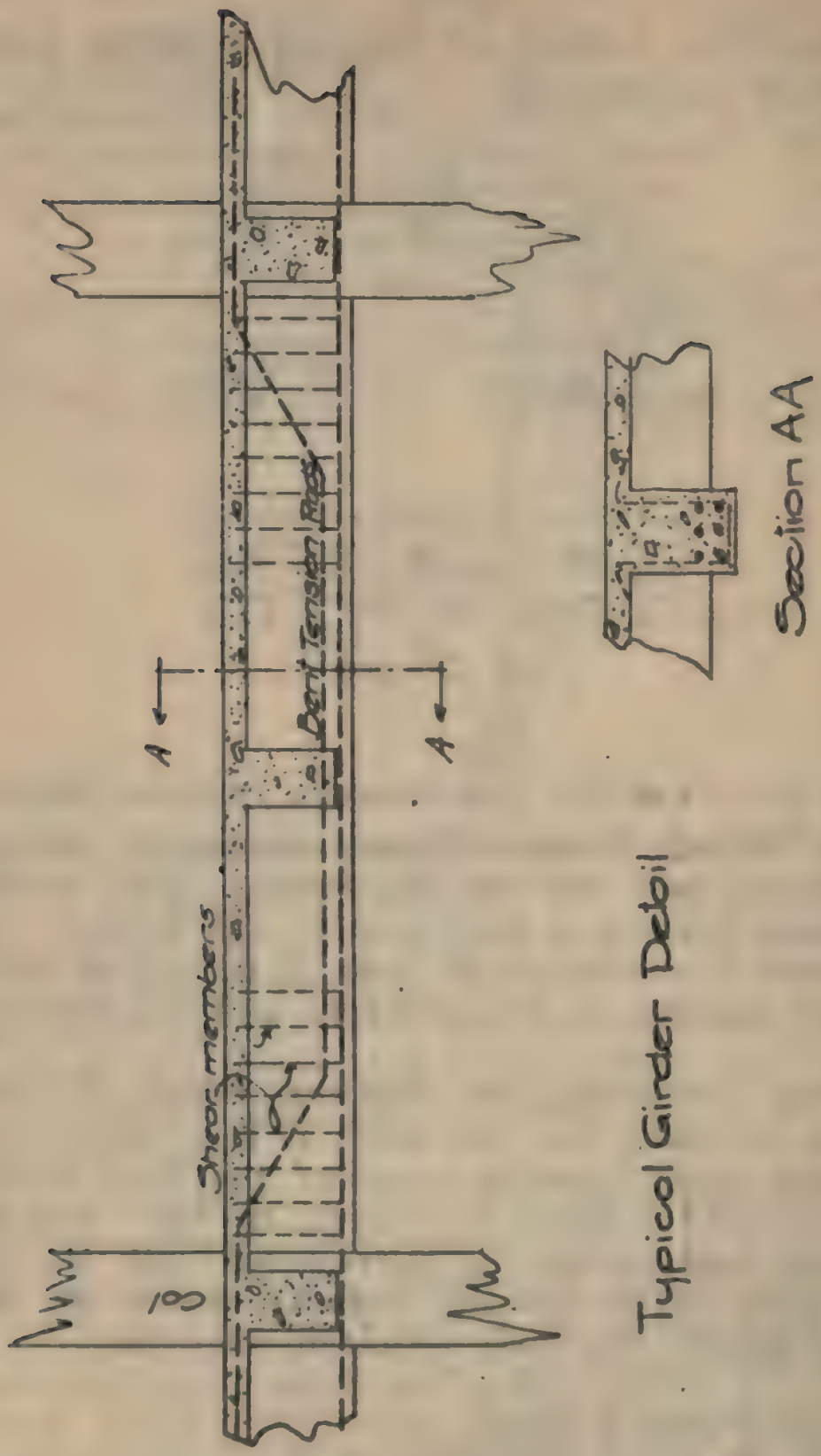


FIG. 18.—DETAIL OF TYPICAL REINFORCED CONCRETE GIRDER.

were. Then with the reinforcing rods correctly tagged many possible errors are avoided. Placing reinforcement with loose rods is delicate work at the best. Use every means to secure accuracy and efficiency.

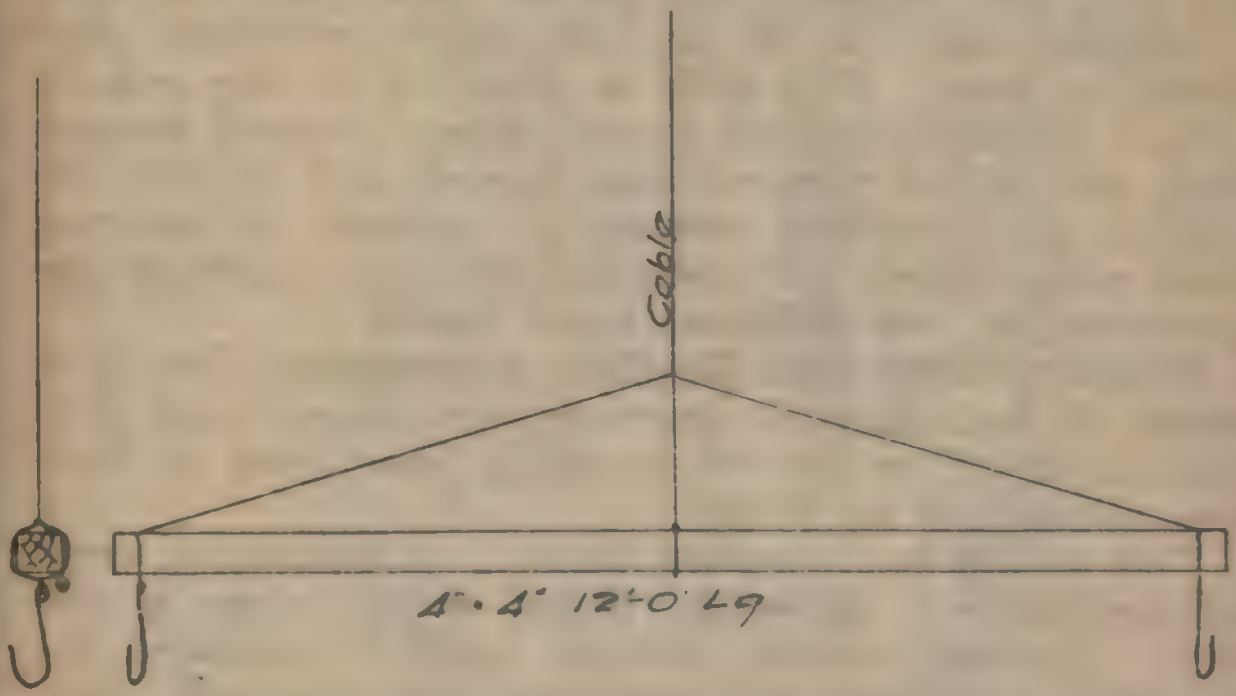


FIG. 20.—USEFUL APPARATUS FOR HOISTING REINFORCING STEEL RODS TO UPPER STORY.

TABLE

Minimum lengths (minimum clear span of beam) required to secure rods and bars against slipping under stated fibre stresses in steel. Adhesion 75 lbs per sq. inch of surface.

Diameter or Thickness	Adhesion per lineal inch		Values of f							
			10,000		16,000		18,000		20,000	
	Bars	Rods	Lengths							
¼ in	750	593	1 ft.	5 in	2 ft.	3 in	2 ft	7 in.	2 ft.	10 in
⅜ "	1125	885	2 "	3 "	3 "	1 "	3 "	9 "	4 "	2 "
½ "	1500	1175	2 "	7 "	4 "	7 "	5 "	2 "	5 "	8 "
⅝ "	1875	1470	3 "	7 "	5 "	8 "	6 "	4 "	7 "	1 "
¾ "	2250	1770	4 "	2 "	6 "	8 "	7 "	6 "	8 "	4 "
⅞ "	2625	2060	4 "	11 "	7 "	10 "	8 "	10 "	9 "	10 "
1 "	3000	2360	5 "	7 "	8 "	11 "	10 "	1 "	11 "	2 "

FIELD MANUFACTURE OF CONCRETE.

Too much importance cannot be attached to the careful selection and grading of the inert materials entering into combination with cement to produce concrete.

Natural sand is, so far, the most commonly used granular inert. The bulk is supplied by the use of gravel, crushed stone of various kinds, crushed furnace slag, etc. What demands our earnest and constant attention is a practical method or methods of securing data upon which to determine the ratio between the quantities of the different sized inerts.

Proportioning and Grading Aggregate.—The volumes of the materials entering into concrete are subject to variations due to handling, conditions of loading, piling and so forth.

The weight is a constant factor. In laboratory work proportioning is generally, if not always, done in this way. Quantities using volume units of measure are not exact, although as conditions are at present, sufficiently accurate to meet the demands of the field.

The ideal concrete is one in which the amount of water is just sufficient to supply all that is needed for the crystallization of the cement; where the amount of this neat cement paste is sufficient to fill every void in the particles of sand and where this mortar of sand and cement is sufficient to fill all the voids in the stone or slag, or whatever aggregate is used. This, then, would be your ideal concrete, dense and waterproof, the maximum strength and quality for the given material. What methods and means can we adopt in actual field construction to secure as nearly as possible this quality of concrete?

For discussion, let us assume the use of a crushed limestone and bank sand. We wish to combine these two materials in such proportions as to secure the most dense combinations.

One method is to determine what is termed the

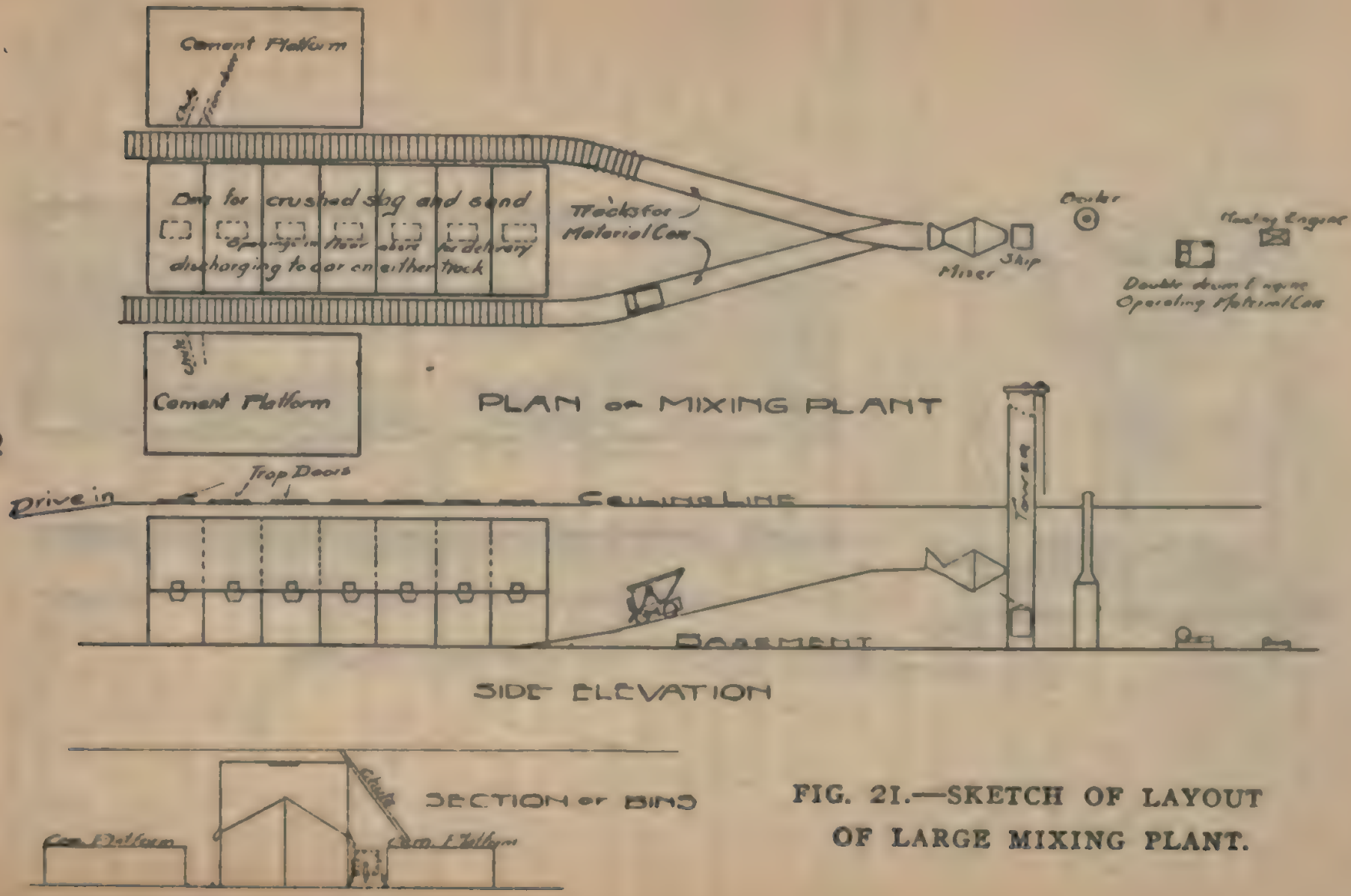
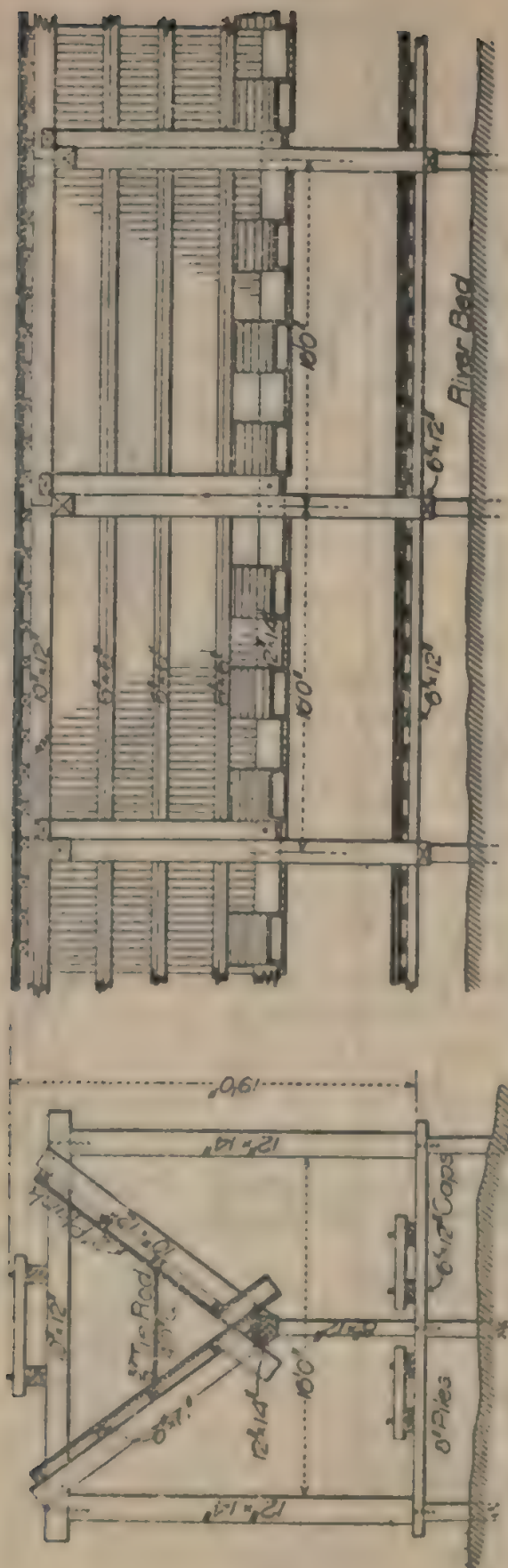


FIG. 21.—SKETCH OF LAYOUT OF LARGE MIXING PLANT.


River Bed
6"x12"
100'
12"x12"
19'0"
5/8" Tie Rod
6"x12" Caps
10'0"
12"x12"
6"x12"
21'0"
12"x12"
12"x12"
21'0"
12"x12"
12"x12"
21'0"
12"x12"
12

"percentage of voids," that is, the number of parts in 100 parts of crushed stone, which are occupied, not by stone, but by air (when it is in the stock pile). We wish to determine this volume in order to tell how much mortar to use. There are two ways of finding this out. One cubic foot of solid limestone weighs 165 lb. Make a wooden box exactly 1 ft. each way, inside measure. Fill it with the broken stone, and weigh it. This weight will vary, determined by the degree of crushing and screening. Assume that you find that 1 cu. ft. of crushed stone weighs 105 lb.

The ratio of 105 to 165, or 63½ per cent, equals the percentage of solid matter.

100%—63½%=36½%, or the "percentage of voids." In other words, 1 cu. ft. of crushed stone requires .36½ cu. ft. of sand and cement to fill all the voids.

This same method can be applied to the sand to determine the percentage of voids. A solid cu. ft. of quartz weighs about 165 lb. and assume the voids in the sand to be 40 per cent. Therefore, 1 cu. ft. of sand requires .40 cu. ft. of a "filler," in this case cement, to make it solid.

If 1 cu. ft. of sand requires .40 cu. ft. of filler, then the .36½ cu. ft. with the 1.0 cu. ft. of stone will require .14½ cu. ft. of "filler" or cement.

We then see that in this case to produce an ideal concrete we could take

1.00 cu. ft. of crushed stone.
.36½ cu. ft. of sand
. .14½ cu. ft. of cement.

These proportions reversed and referred to 1 cu. ft. of cement as a base, give us a proportion of 1 cu. ft. of cement, 2.7 cu. ft. of sand and 6.9 cu. ft. of stone. For better work, increase the proportion of the cement to provide for the cement used to coat the surface of the stone. Also as a factor of safety, as it were, increase the proportion of sand.

In the above method we found the percentage of voids by weighing a certain volume of material. Note the following parallel methods and results:

Take a wash boiler or a water tight container of approximately that size—a water barrel would do if there were nothing better.

18 in. or so from the bottom drill a hole and put in a spout, sufficiently long to carry the water into a graduated glass standing beside the container.

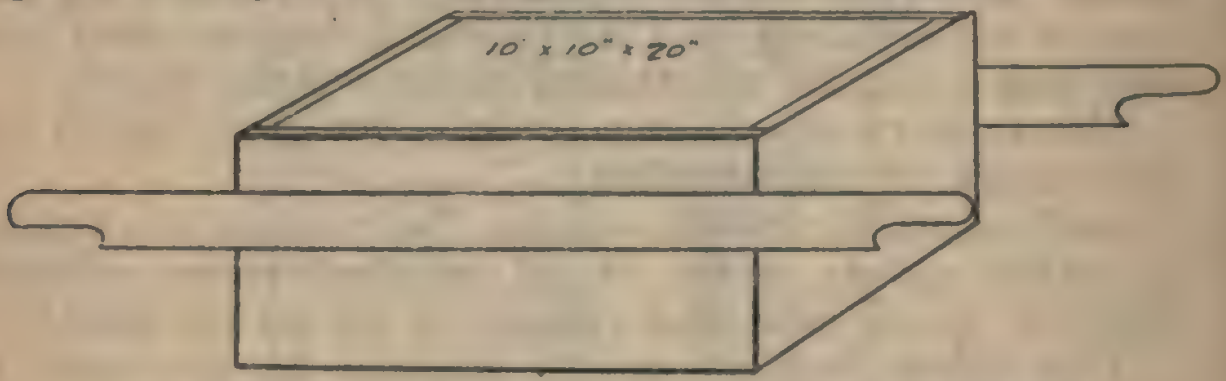


FIG. 23.—BOX FOR MEASURING MATERIALS.

A wooden box 10 in. by 10 in. by 20 in. containing 2,000 cu. in. (a little over 1 cu. ft.) can be made. Secure a 1 gallon measure and a small graduate glass (cu. inches) to measure less than a gallon.

To determine the voids in crushed stone or any aggregate or sand, proceed as follows: By filling up the barrel until water runs out of the spout, and then letting it run out until the surface is level with the opening, we have a constant volume of water. Now fill the box with the crushed stone. Pour the stone slowly into the barrel, and measure the overflow in the gallon measure. Use care to stop up the hole when you are emptying measures, if a small measure is used. There are 231 cu. in. in a gallon and you can determine the number of cubic inches of water displaced by multiplying the gallons by 231, and adding the remainder as measured in the graduate glass. It is self-evident that this volume of water displaced is equal to the exact volume of solid material in the 2,000 cu. in. of

stone put into the barrel. Assume that 5 gallons of water were displaced and 42 cu. in. measured in the graduate as the final fraction of a gallon.

$5 \times 231 = 1155$
Graduate $= 42$

1197 cu. in. (call it 1200).

Therefore there are 1200 cu. in. of solid stone in 2000 cu. in. of crushed stone. The voids are 800 parts in 2,000 or 40 parts in 100, 40 per cent.

The same method can be applied to sand or any aggregate, and the method of working this out is the same as noted previously, the only difference being that the amount of solid material in a certain volume is determined by water displacement instead of by weight. One uncertain factor in this last is the ability of certain stones to absorb water, which would affect the results, consequently the stone should be wet before the test.

These are two commonly accepted methods of determining the amount of voids, and the proportion required between the sand and the bulk aggregate.

In carrying on these tests, be very careful to use samples that are the average run of the stock. Wheel a barrow around the pile and take a small shovelful from different localities, middle and edges. Then mix this thoroughly in the barrow, and use it for the sample.

The simplest and most effective way of applying either of the above methods to obtain a proportion between the sand and aggregate is by experiment. Voids in broken stone run generally between 40 and 50 per cent. As specifications come now into the field, the mix is usually specified as 1-2-4 or 1-2½-5, fixing arbitrarily the proportion between the sand and the larger aggregate. To check on this it is a good plan to experiment with the water

displacement apparatus. The mix has been specified in an office before any material was received on the work and is consequently little more than an assumption. So many conditions, such as loading, crushing, etc., enter into the grade of the aggregate. Perhaps it runs too fine, and the specified mix, say 1-2-4, runs too high in sand. Make a mixture without cement of 2 parts of sand to 5 parts of stone, and see whether or not this weighs more or displaces more water than a mixture of 2 parts of sand to 4 parts of stone. If the stone is large and unusually clean a 2 to 4 combination might not be nearly as dense (i. e., displace as much water, or weigh as much) as a 2 to 3 combination.

By all means use the proportion between sand and stone, which is the most dense. This means a combination in such proportions to weigh the most, or displace the most water for a given volume.

Here we simply have touched upon an elemental field-method of determining "voids by water displacement." Using a box 10 in. x 10 in. x 10 in. would give 1,000 cu. in. and the ratio could be figured direct. For active field work, however, experimenting with different proportions and determining which of these are the most dense, is undoubtedly the best way. If a 1-2-4 mix is specified and the stone is too large and clean to give you a well graded concrete, you are, we believe, on consultation with the office, justified in the interests of good work, in interpreting this to mean 1 part of cement to 6 parts of sand and stone, and determining the ratio between the sand and stone by experiment.

Mixing Plants.—The layout of the mixing plant is a question which cannot be decided on paper or in any book, no matter what its size. Each piece of work is a new problem, and it behooves the field superintendent to study well the conditions, analyze the component factors and realize the results to be obtained.

The essential machinery, in general, is a mixer and hoist, with their power, steam, gasoline or electricity as it may be. The machinery must be located somewhere between your raw material, sand and aggregate, and your product, the concrete in the pouring; keep before you always the fact that the material from cement shed and sand-pile, to concrete in the forms, must be handled the least number of times.

Handling Material.—It seems as though light portable mast derricks could be used economically to handle concrete materials, both in front of and behind the mixer. Bottom or side dumping buckets are coming into general use, and small commercial railways. It will pay the construction man to study thoroughly any piece of work and decide upon the most efficient way of handling his material—cableways, tramway, derrick, wheelbarrows or gravity. Consider the merit and comparative efficiency of each method.

Use gravity to save labor; make the attraction of the earth move your aggregate into the mixer. In other words, put your mixer as low as possible in order to avoid wheeling up steep inclines.

Put the mixer in the excavation and dump the materials in the street outside. Load into the hopper behind the mixer with barrows, buggies or belt conveyors.

When the machinery is located below ground, or whenever material is handled over the mixer or engine, the flooring over the mixer should be grit-tight. Place a guard rail around any opening, such as required for boiler stack, etc.

Laborers will shovel more crushed stone if planks are laid on the ground. Clean all rubbish off the site for your stock pile before unloading sand or stone. This rubbish will work up into the material and consequently appear in the concrete.

Bringing cars of material as closely to the mixing plant as possible will save labor in handling concrete materials.

Breakdowns.—In laying out and setting up a mixing plant, always anticipate the inevitable breakdown, and its effect on the progress of the work. In a case of breakdown of the feeding machinery, have an auxiliary supply of material available. In case the mixer breaks, have a mixing board ready and if necessary keep the work going by hand.

Feeding the Mixer.—We cannot too strongly urge more exact and positively accurate methods of feeding the mixer. A few years ago, our "best" methods were hardly better than guess work, and the results depended entirely upon the intelligence and constant vigilance of the "man behind the mixer." It will pay any man in the field to keep in constant touch with the new developments in this line, which is easily done through the medium of the trade publications. Send for these and study them, for the machinery described usually represents the very latest, the "last words," as it were, on this matter.

Wheelbarrow Measurements.—Do not depend on wheelbarrow measurement to establish your proportions of sand and slag, for that is little more than guess work. It is far better to enter the sand and slag into separate compartments of a hopper, the division slide of which can be adjusted to meet different grades of material, then adding the proper amount of cement, usually determined by the number of sacks of 1 cu. ft. each, to place this entire batch correctly proportioned and carefully checked, into the mixer at one operation.

Measuring sand and stone by wheelbarrows is an inaccurate approximation. If it must be done, make a cube box without a bottom along the same line as previously mentioned, only small enough to get in a barrow and of an exact size to contain when struck, a specified number of cubic feet. Place this form on the barrow, fill it to a struck surface, remove the frame

and there is an exact quantity of sand or stone in the barrow.

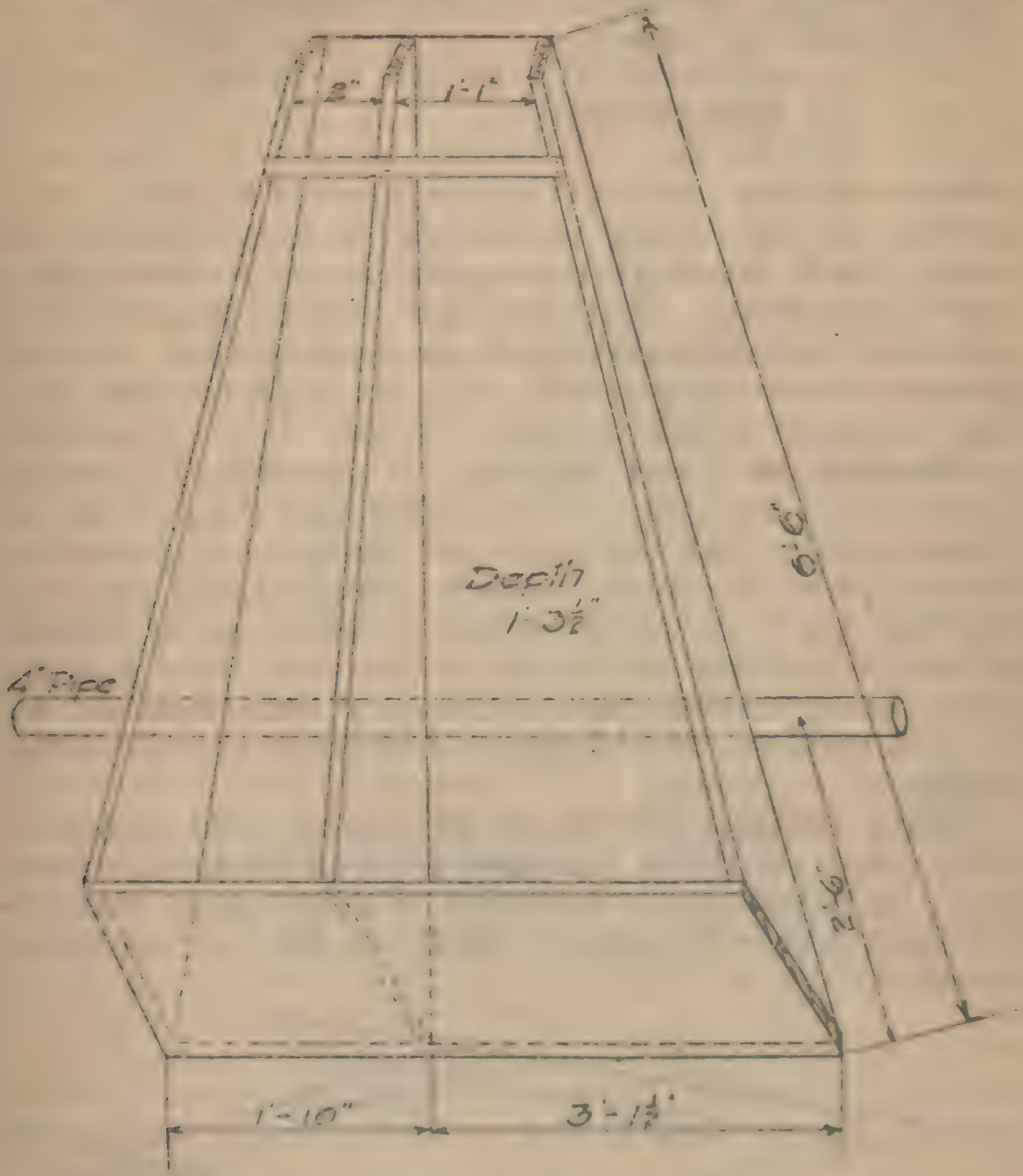


FIG. 24.—FIELD-MADE SIDE LOADER AND MEASURING HOPPER.

Field Made Hopper.—A field made hopper is shown in the accompanying sketch. Adapt this idea to meet any conditions.

Mixers.—A word as to different kinds of mixers. They naturally group under the following heads with self-explanatory names:

(1) Gravity,
(2) Continuous,
(3) Batch.

It is uncalled for in this work to enter into a comparison of the relative merits of these machines. As noted, trade publications usually go into details much more extensively. The same rules as to proportioning the sand and aggregate apply in these mixers. A continuous, however, naturally requires a continuous feeding, correctly proportioned.

Machine or Hand Mixing.—It is perhaps pertinent at this time, to invite consideration and thought on the relative values of machine and hand mixed concrete. There are on the market today so many small machines run by hand or small engines, and even a traction mixer, which can be loaded at the stock pile and mix while being driven, that it seems a little uncalled for to still employ the old method of hand shovel or hoe mixing.

Hand Mixing.—If hand mixing is used, however, take every precaution to have a carefully proportioned mix. A frame is the best way of determining the proportions required, using 1 cu. ft. as the unit of measurement.

FIG. 25.—FRAME FOR MEASURING MATERIALS ON THE MIXING BOARD.

One cu. ft. contains 12 x 12 x 12 = 1728 cu. inches. A frame 36 in. x 48 in. (3 ft. by 4 ft.) by 1 in. high, also contains 1728 cu. in. or 1 cu. ft. Therefore a frame, as shown in fig. 25, 3 ft. x 4 ft. x 2 in. high, will contain 2 cu. ft. of sand when filled and struck. One sack of cement placed on top of this, spread evenly and then, with the frame removed, thoroughly mixed, would give an exact 1 to 2 mix. Another frame could be built to contain 4 cu. ft. Make this 3 ft. by 4 ft. by 4 in. high or 6 ft. x 4 ft. by 2 in. high. While the men are turning over the sand and cement, another man can be filling the 4 in. frame with crushed stone, striking this off, and wetting it. When the sand and cement are turned for the last time, shovel it on top of the 4 cu. ft. of stone and mix together.

Always, if possible, wet the stone before mixing. If you are cramped for room, or short of men, put one frame on top of the other and assemble an entire batch at once, 4 in. of stone in the bottom frame, then strike this. Put on the 2 in. frame and put in 2 in. of sand. Then spread a sack of cement over the top, lift the frames and start in to mix. The heights of the frame determine the proportion to one sack or 1 cu. ft. of cement, because, as noted above, a frame 36 in. by 48 in. by 1 in. high contains 1728 cu. in. or 1 cu. ft.

Throughout this discussion, we have used sand and stone as typical inerts. The same conditions apply, whatever aggregates are used.

In hand or machine mixing, always have an experienced man watching the concrete. This is a constant check and is a factor for safety that cannot be dispensed with.

Concrete Hoisting Towers.—There are on the market today, and well illustrated in trade publications, so many good combinations to elevate concrete to the required floor level, that a discussion here is hardly called for. A field-made tower with 4 x 4 uprights for the corners, and sufficient cross bracing, is in general

use. A tower made as follows proved very satisfactory. Instead of using 4 x 4 for the corner posts, angles made out of 2 x 6 and 2 x 8 like the illustration were

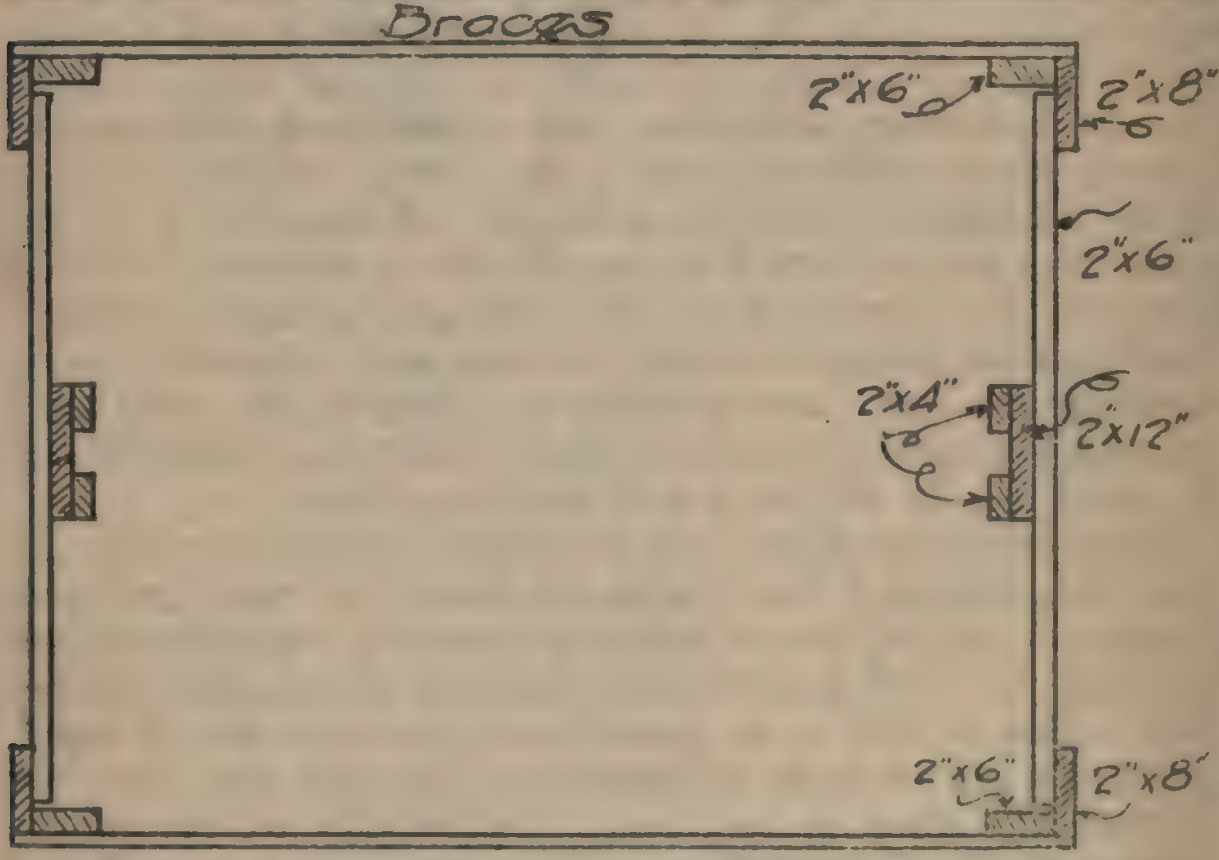


FIG. 26.—DESIGN OF TOWER FOR CONCRETE HOIST.

used. These were equal legged angles facing in, and allowed for diagonal and cross bracing very well.

A 2 x 12 surfaced, with 2 x 4's, made a very good guide.

The bucket was tripped by hand at the top, and dumped into a field-made hopper with a sliding gate.

Field Made Hoist.—An ordinary mason's hoist has been converted into a concrete elevator by a rocking cradle as shown in the accompanying sketch. This is framed out of any timber on the job, and will prove a handy outfit. A vertical wire, run through an auger hole in the end with a stop on it at the proper height will dump the cradle where you want it. Any shoulder or attachment would do the same. Use a hopper up above as on ordinary work.

Placing Concrete.—The first thing to consider in placing concrete is the runways. Build good runways and support them away from the steel.

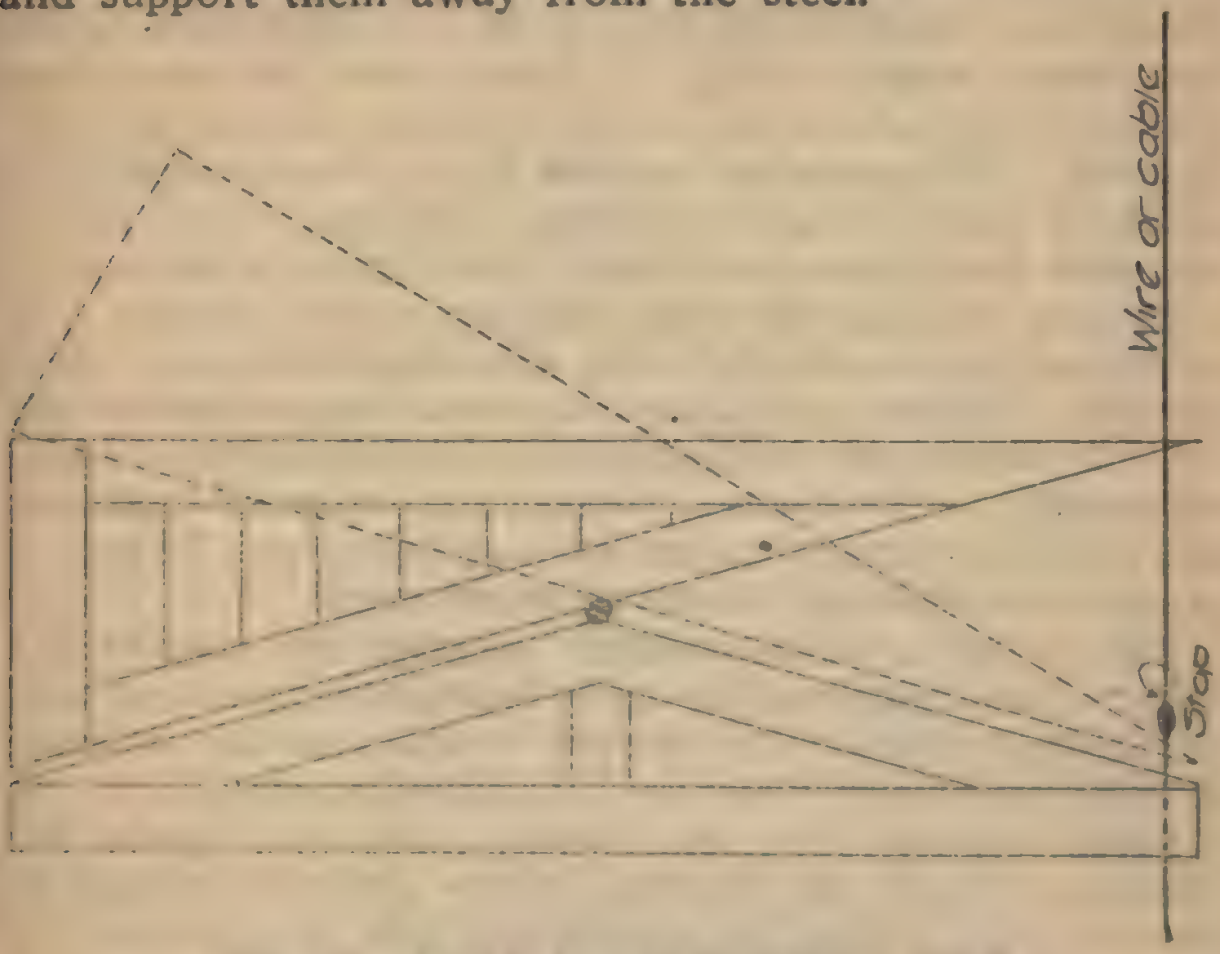


FIG. 27.—FIELD-MADE HOISTING SKIP.

An inch board down the middle of a 2-plank wheelbarrow runway is a good plan, as it keeps the plank from spreading. Cleats along the edge keep the buggy from running off and dropping down on the steel to injure it. They also assist in dumping by blocking the wheels.

When using wheelbarrows, buy those with a high front and "points" to use in dumping.

In working on places where a misstep off the run would mean a fall, injuring both the wheeler and the man underneath, it is only fair to put up a strong guard rail.

Centering, unless oiled or otherwise prepared should be soaked with water before running concrete. Clean

out the forms with a hose-stream under good pressure. Steam is very good, especially in winter.

It is good practice to first sweep the forms of all loose and large objects taking care to keep away from the beam boxes. Pick all blocks out of beam and girder boxes with a spear; ¼ in. steel rod sharpened, is good. The water boy can do this. For fine shavings, sawdust and dirt use the hose, and slush them into a wet pile and lift out of beam with a hand trowel.

Before starting to run concrete, check forms and reinforcement carefully. See that the forms are oiled or wet. Station an experienced man down below the floor to watch the centering for a failure and hold him responsible. In beam, girder and column bottoms, start with a batch of sand cement concrete. This is a precaution which will insure better work.

Never run a beam without running the slab at the same time, because the slab immediately above and adjacent to the beam is figured to take the compressive stresses and there must be a continuous section.

Have a good man to receive, place and spade the material. Train the laborers not to dump their cart or barrow until spoken to, and at the spot designated. In this way the concrete is placed systematically, and a better, evener job is secured. Never place any concrete except under the supervision of responsible men to insure the correct position of the steel.

In using buckets or tram-cars, take every precaution not to jar any green concrete, or the concrete of the floor below. This is absolutely imperative.

Hold a man responsible for the appearance of the finished surface. Use tamps made of 1-in. boards, 2 or 3 inches wide and put plenty of men at tamping.

For work which must be waterproof a continuous run is necessary. If it is required to stop work before the run is completed, be careful to have clean joints in starting work.

Concrete in Columns.—Light a candle at the bottom of the column through the handhole and have a responsible man look down into it from the top. Keep a responsible man with his eye on each column after it is inspected in this way and until it is run.

Watch the mix going into the columns. If it is wet enough to run and yet dry enough to stick, and the column is obstructed by poorly designed steel, you encounter a bad combination that has to be taken care of. Watch that your mix is of the right consistency and tamp, tamp with 1 x 2-in. wooden sticks all the time. The reinforcement must be concentric with the column.

Use four tamps at once, one on each side of the column. Use two at the very least if the concrete is coming in very rapidly. Tap the column centering with mallets while running, to work out air bubbles.

Concrete in Running Water.—When placing concrete into forms the exterior surface of which is exposed to running water, use every precaution to make the forms water tight. This is imperative, as running water will wash out the cement, and leave an aggregate, good to use behind the mixer, but not in the bottom of a column to support a structure.

Concrete in Beams and Girders.—Use care to secure a good placement of concrete below the girder steel on floor concrete. A batch of sand and cement along the bottom of every beam will help a great deal.

Top Surface.—Use care to leave the top surface of the floor while running in a level workmanlike manner. Use a straight edge and guards if practicable. Snow-shovels have been used to good advantage in leveling floors.

Floors Wet.—Keep the floors wet after running concrete. Barrels filled with water with a partly plugged bung-hole can be left out on the floor to keep it wet.

Record of Concrete.—On large work use some system of marking the floor with the date on which it

was poured. Keep also a record in your field book, or marked plainly on the blue prints.

FREEZING WEATHER.

The end to be attained is to keep the temperature of the wet concrete above the freezing point until the "set" will have advanced to the point where there is no "free" water in the concrete. This is done either by heating the aggregates to such a point as to retain in them enough heat to keep the mass above freezing point until after sufficient set has taken place, or by protecting the concrete in the forms from frost, or by using salt in the mix. The best method is a combination of the most practical features of those mentioned.

The best method is a combination of the most practical features of the other two.

Heat your sand and gravel by steam pipes by placing in hoppers with double bottoms or long kilns, roughly made out of cylinders of steel are also used.

Run a live steam line down into the water barrel to heat the water.

Use salt (sodium chloride) or calcium chloride to lower the freezing point of the water—about a pound or so of calcium chloride to a sack of cement.

Using these precautions so far mentioned, concrete should come to the barrows about as warm as milk, or warmer. After it is in the forms, use every precaution to keep the frost away from it.

On floor work, close all window openings on the floor below with boards or muslin and place salamanders or build wood fires. In using salamanders, be careful not to expose the men to the gases liberated. As the floor is run spread a thin building paper and cover up with straw, shavings or manure. On wall work, hang canvas outside of the centering and run steam pipes or build fires between the canvas and the centering.

Cover the top with empty paper cement sacks, building paper or any other handy material.

HOT WEATHER.

Concrete, to be of good quality, must set slowly and with plenty of moisture present. Rapid drying does not provide sufficient water for proper crystallization and to insure the safety of concrete installed in the hot seasons it becomes of vital importance to protect the fresh concrete from the effect of the direct heat rays in every practicable way. Both forms and concrete should be kept soaked with water and the placings should be shaded with awnings; and if this is not possible the surface covered, as soon as placed, with cloths which should be kept soaked with water and the place where operation ceased at any time during the day or at the end of the day's work covered with rags. During the night a man should be kept on the job expressly for the purpose of keeping everything thoroughly wetted.

Concrete should be flushed thoroughly at night and early morning, for at least a week after placing, and left to dry off naturally during the day, no water being applied while the rays of the sun are pouring upon it, for the generation of steam will be sure to disintegrate the surface.

FIELD NOTES.

Acid Fumes.—The fumes from acid or a spilt or broken bottle of acid will ruin clothing and ropes and tools. It is best to keep acid out of the locker and in a safe place.

Blue Prints.—It is a good plan to enter on the reverse of the blue print the date and from whom received. This will prevent a substitution without the superintendent's knowledge of blue prints covering changes in the work.

Borrowing Tools.—Discourage as much as possible the habit of borrowing tools among fellow mechanics.

For laborers, assign each one a shovel or other tool, and hold him responsible. For smaller tools such as a claw hammer, used in cleaning centering, and wire pliers in lacing steel, which are usually furnished laborers by the contractor, it is usually necessary to charge these to the laborers, and hold them financially responsible.

Branding Tools.—It is economy to spend time in branding tools as they come onto the work. This anticipates all future disputes over ownership, and is also good work for the stead men on rainy days.

Cleaning Concrete from Brick Walls.—A blacksmith can make scrapers from ¼-in. x 1½-in. strap steel, sharpened and tempered. These will do very well for this work.

Whenever using acid, always soak the wall thoroughly with water. This not only lessens the quantity of acid required, but prevents the acid from soaking into mortar joints, and reappearing as a white salt.

Cleaning Mixer.—Throw a pail of water in the mixer at noon to clean out loose concrete. Clean out thoroughly at night. You can save time by starting in the mixer crew 5 minutes ahead of the rest of the men, and have a batch ready in the hopper when the other men start work.

Concrete Blocks for Spacers.—Concrete blocks should be used whenever possible in place of wood or metal as spacers, such as between wall forms, below and between the tiers of girder and beam reinforcing rods, to keep slab rods off the centering, and to keep the bottom board away from the I-beam in fireproof steel construction. Wooden blocks should not be used unless absolutely necessary, for the reason that, remaining in the concrete, as they are liable to do, a weak spot is developed. Steel should not be used to come to the surface of the concrete. This may develop a rust spot, and act also to convey heat to the reinforcing steel, causing unequal expansion.

Co-operation Between Trades.—There is hardly anything that we can say on this question which you do not already know if you would stop to think.

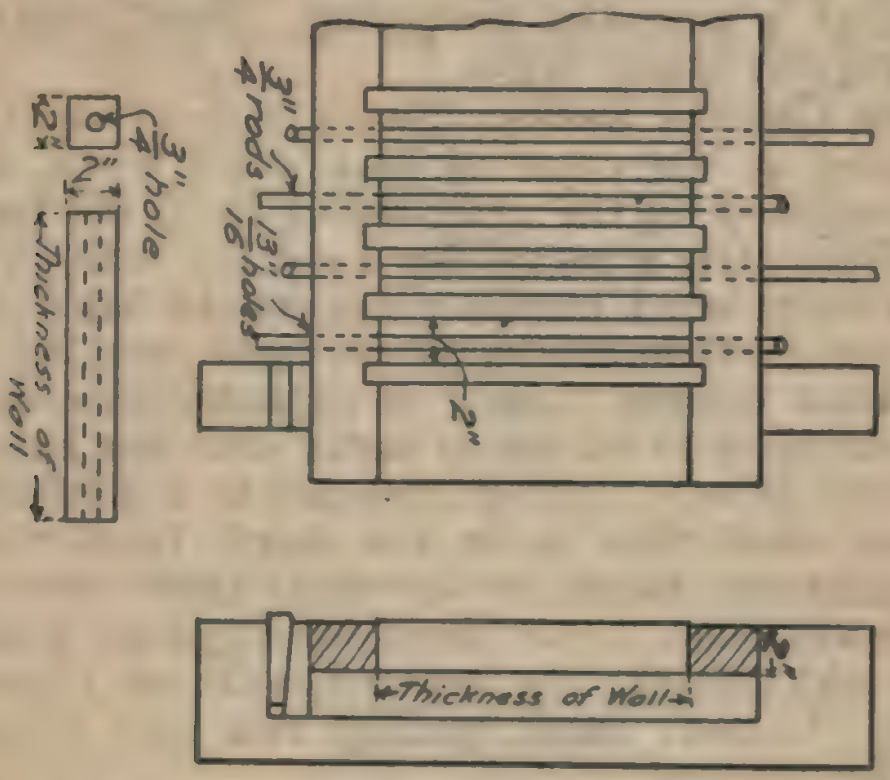


FIG. 28.—DETAIL SHOWING MOLD FOR FIELD-MADE CONCRETE WALL SEPARATORS.

On construction, each trade has its place. The building is incomplete unless each part of it is finished up in workmanlike manner. Harmony and co-operation and the application of the Golden Rule will make the work go easier. Never take advantage of the other fellow's failure to be on the job, to put in your work to his disadvantage, at least unless absolutely necessary, and then not without fair warning. Do not countenance in your employes what you would not do yourself. You would not deliberately steal a fellow-contractor's material or tools. Don't let your men do so. Work together to put up the best structure you can.

Cutting Holes.—Do not cut holes at random in a concrete structure. There are structural requirements in the placing of all material. Frame all openings in

during construction and take care of stresses as noted under Steel Fabrication and Placing.

Drills for Concrete.—For drilling soft concrete any blacksmith can make a pipe drill by cutting notches in the end of a pipe and tempering. Hard concrete requires regular stone drills.

Empty Cement Sacks.—Empty cement sacks should be counted at the close of each day's work, and the number entered on the daily report or in the field book as required. On a rainy day have the man in charge of the cement shed bundle these flat in bundles of 50, and return them in this way. Freight must be prepaid on returned cement sacks. A common way of taking care of these is to bunch 19 sacks into one empty sack and tie the mouth, making 20 sacks in a bundle.

At any rate, cloth sacks are worth from 7½ to 10 cents apiece and should be carefully taken care of. The laborers will want to use them for leggings, tying them around with string; the masons will use them for a tool kit. Cement sacks quickly run into money and should be watched.

ENGINES.

Engineer.—It is economy to employ an experienced engineer and put him in charge, holding him responsible at all times for the condition and efficiency of his plant. In turning over tools to him, furnish a correct list of the outfit. Have this typewritten in the office and pasted on the inside of the tool box cover.

Blowing Down.—Watch your engineer on blowing down boilers, and do not let him fill the boiler again until it is cool. This extreme change of temperature within a short time limit sets up internal strains which shorten the life of a boiler. Watch the quality of the steam. Wet steam usually means overloaded boilers. Instruct your engineer to try the safety valve every day.

Boxing Gears.—Construction work, and especially concrete construction, usually goes on in a hurry with a number of participating laborers. Take pains to cover with well made boxes the gears of the mixer and any other gears or drives, especially those adjacent to the men. This is good insurance against accidents and pays in the long run.

Coal Needed for Boiler.—Approximately 12 lb. of soft coal for 1 sq. ft. of grate surface for every hour.

Covering Stack.—Between times of running concrete or other times, when the mixer is out of use for a few days, put any empty nail keg or a board over the stack to prevent rain from rusting the flues.

Flues.—Keep the boiler flues clean. The writer has used a blower shaped like an L with 48 in. and 24 in. arms, made on the job from ¾-in. water pipe and a piece of hose. This is convenient and inexpensive.

HORSE POWER.

Vertical Engines.	Size of Cylinder.	Rev. per Minute.
4 H. P.	4 in. x 5 in.	250
5 H. P.	5 in. x 5 in.	225
10 H. P.	7 in. x 7 in.	190
15 H. P.	8 in. x 8 in.	180
20 H. P.	9 in. x 9 in.	160
25 H. P.	10 in. x 10 in.	160
Horizontal Engines.		
6 H. P.	4 in. x 6 in.	260
8 H. P.	5 in. x 8 in.	240
10 H. P.	6 in. x 9 in.	200
15 H. P.	8 in. x 10 in.	190
20 H. P.	9 in. x 12 in.	190
25 H. P.	10 in. x 12 in.	190
30 H. P.	11 in. x 15 in.	190

Low Water.—If during accidental or unavoidable absence of the engineer from the work, the boiler should be found with low water, immediately shut off

the draft and cover with ashes or pull the fire. Be careful how you start water into a boiler.

Precaution for a Cold Night.—On a cold night, or a night liable to frost, see that the engineer leaves no water in the glasses.

Water Barrels.—The water barrels from which the boilers are fed should be kept completely covered excepting an opening for the injector pipe. Keep this barrel clean. The men should not wash their hands in it.

Water Needed for Boiler.—To find the water required for the boiler multiply the H. P. of the boiler by 30, which gives the pounds of water per hour. Divide by 8, which gives the number of gallons per hour.

$$\frac{\text{Boiler H. P.} \times 30}{8} = \text{Gals. per hour needed.}$$

Fire Insurance.—The centering nearing completion on a large unit of work represents a heavy investment in labor and material, and it might be well under certain circumstances to protect this centering with fire insurance. The insurance should also cover the plant and machinery.

It is a good plan to have the hose on for fire protection. Have a tank or stand pipe on top of the concrete tower, where there is no hydrant pressure.

FREIGHT.

Shipping, Tools, Equipment and Material.—When shipping equipment, engines and mixers, see that all detachable parts are removed. This will anticipate their theft and save trouble. Be sure to brace everything solid when shipping equipment to avoid breakage.

Find out from local freight men the height allowed above deck of flat car for bridge clearance, etc.

In loading a mixer on a flat car it is a good method to build a crib out of runway planks and elevate your

machinery on this. Then block the equipment with the planks and use these again to unload. Be careful in unloading not to let the mixer get away from you. A tackle and block to the other side of the car is a precaution to protect the men.

A box car is best for an ordinary outfit, including a mixer and boiler if you can get a large enough one. The mixer stripped with the hopper taken off, will get in a door by close fitting. Less danger of theft in a box car.

Following are extracts from the Car Service and Demurrage Rules as in use in Ohio. Approximately the same conditions govern throughout the country.

The railroad is required by law to notify the consignee of the arrival of freight. This notice must contain the weight and amount of freight or other charge. In carload shipments initials and number of car must be entered on this notice. A second notice must be given, noting time and location of placement, unless this item is contained in the first notice.

"When cars are placed for loading or unloading on public delivery tracks or on private sidings, (the railroad performing the service) 48 hours free time will be allowed on cars containing not more than 66,000 pounds, and 72 hours for cars containing more than 66,000 pounds. Only 48 hours allowed on Interstate business.

"When consignor has only 48 hours free time for loading and additional time is necessary to comply with the rules of the carrier as to blocking, bracing or planking the carload, 24 hours shall be allowed as such additional time.

"Twenty-four hours are also allowed for reconsignment or amended instruction, and when cars are detained on account of incorrect billing.

"A charge of $1 per day will be assessed, after expiration of free time above mentioned.

"Whenever, on account of the severity or inclemency of the weather it is impossible or impracticable to secure or use the means of loading or unloading, or whenever, on account of the severity or inclemency of the weather, removal would cause material damage to the freight, additional free time shall be allowed equal to the time lost by reason of such severe or inclement weather. Said additional free time shall be allowed whether said weather conditions interfering with loading or unloading occur within or after expiration of free time: Provided that not more than five days additional free time shall be allowed on one car.

"In computing time, Sundays and the following holidays will be excluded:

"New Year's Day, Washington's Birthday, Decoration Day, Fourth of July, Labor Day, Thanksgiving Day, Christmas, and general election days.

"When any of these holidays occur on Sunday, the following Monday will be excluded.

"Time is computed under the following conditions:

"(a) Time will be computed from the first 7:00 a. m. after cars are placed on public tracks for loading.

"(b) Time will be computed from the first 7:00 a. m. after date of notice to consignee of arrival when cars are held for orders, or from the first 7:00 a. m. after placing on public tracks when cars are held for unloading.

"(c) On cars to be delivered on private tracks, time will be computed from the first 7:00 a. m. after actual or constructive placement on such tracks.

"(d) On cars to be delivered on interchange tracks of minor railroads or industrial plants, performing their own switching service, the time will be computed from the first 7:00 a. m. following delivery on such interchange tracks, until returned thereto.

"Cars are not subject to orders for loading, either by the owners of the property contained therein or by any other shipper until they are empty.

"Cars consigned to, or ordered to private sidings, shall be considered to have been delivered, either when such cars have been placed on the tracks designated, or when they would have been placed but for some condition attributable to consignors or consignees.

"The railroad will refuse to receive loaded cars unless accompanied by billing instructions. Car service charges due upon cars ordered forward, either in regular or switching service, must be collected before shipping instructions are accepted and bill of lading signed.

If any patron elects, the carrier shall enter into an agreement with him to apply the so-called average plan for the determination and settlement of car service charges, the basis of the average to be 48 hours, fractions of days not to be taken into account, a credit of one day in time to be given on each car loaded or unloaded within 24 hours, such credit to be applied on cars detained more than 48 hours; no one car to be entitled to more than seven days' free time; balances to be closed at the end of each calendar month. This applies only to interstate business.

Do not make any shipments in anticipation of a contract or before all necessary arrangements have been made at destination for the unloading of car. Let the goods be forwarded on a bonafide contract and know that car will be released promptly at destination.

It is the duty of both the shipper and consignee to load and unload car as promptly as is possible, and the mere fact that the Demurrage Rules make a 48-hour allowance does not mean that cars should be held arbitrarily that length of time. The prompt loading and unloading facilitate movement of cars.

Gasoline.—Gasoline should of course be kept in a separate building. Covering the gasoline barrel with oil cloth or damp sacks will ward off sparks and also prevent evaporation.

Inventories.—In shipping tools and equipment have a complete inventory made. Check this with the last

inventory. On small pieces of work, inventories are made only upon starting and finishing a job. Inventories made more often, once a month or so, may save buying tools by acting as a check on theft or careless loss and are really economy.

Ladders.—All ladders on the job, such as up the concrete tower, etc., should be built uniformly. Adopt a standard (12-in. is good) for all risers and always use it. This is important and will save accidents.

Liability Insurance.—Liability Insurance may be regarded as a necessity to any well regulated and prudently managed construction enterprise. A chain is only as strong as its weakest link; and the employer, in his relation to third parties is only as careful as his most negligent employee. Through an accident, caused by the negligence of another, an employer might sustain a heavy loss. Liability Insurance is designed to protect employers against loss arising from accidents to employees or to the public. The trend of legislation shows the growing tendency to hold employers accountable for injuries sustained by employees, or the public through the negligence of such employees.

Measuring Pole.—A pole, 8 or 10 feet long, graduated to ¼ or ⅛ inches is handy to use in laying out or measuring up work where the accuracy of a steel tape is not needed. For all approximate measurements this is an efficient tool.

Permits.—Take precautions to always secure beforehand the necessary construction permits. The handiest way to file these is to batten them on the inside wall of the shed with an old piece of window glass over them. They are then always accessible to the inspecting patrolman.

Photographs.—An ordinary film kodak is the handiest for construction work, and a time exposure when possible, gives the best results. The smallest opening with a long exposure gives the clearest picture. For such an exposure place the camera on a solid support

and expose, say anywhere from 1 to 30 seconds on a bright day and 5 to 10 minutes on a dull day. More time is required for interior exposure. Never point the camera toward a light window in an interior. This is liable to "fog" the film.

For snap shots in bright exteriors or of moving objects, use the largest opening and the quickest shutter. A snap exposure of an interior is impossible.

In using a film camera, load it in a darkened place, and always turn the film to the next one immediately after the exposure. When a film is completed always record the date and place and any other data on the gum sticker, and instruct the developer to letter this on each film. It is thus recorded on every print.

Pointing-Up.—It is well to examine all concrete surfaces after removing centering and before pointing up. If you can't do this, put a man you can trust on this work so that he will not, without advising you, cover up any structural weakness.

Precaution for Work of Other Trades.—Concrete once set is very hard. Its form is, except superficially, unchangeable and to cut or fit concrete to any of the other trades is very expensive and unsatisfactory. Any attachments must be thought of beforehand and the proper forms placed.

A well accepted method of taking care of steam fitting is to use a galvanized iron sleeve somewhat larger than the pipe and longer than the thickness of the concrete. Slit the ends and spread to allow for nailing. Put these in horizontally through the beams on the line of pipe and vertically through the floor at risers. By all means get the steam fitter onto the work before you pour concrete.

Get the electrician onto the job and have him place his outlet boxes, and run his conduits in the concrete floor, *over* the steel reinforcement.

Record of Efficient Men.—The advantage of keeping a record of your best men and knowing where to

find them when you want them is apparent. You have spent much time and money to train these men and, to be able to refer to a complete list of these "helpers" and to find the right man at the right time tends toward better organization and efficient work.

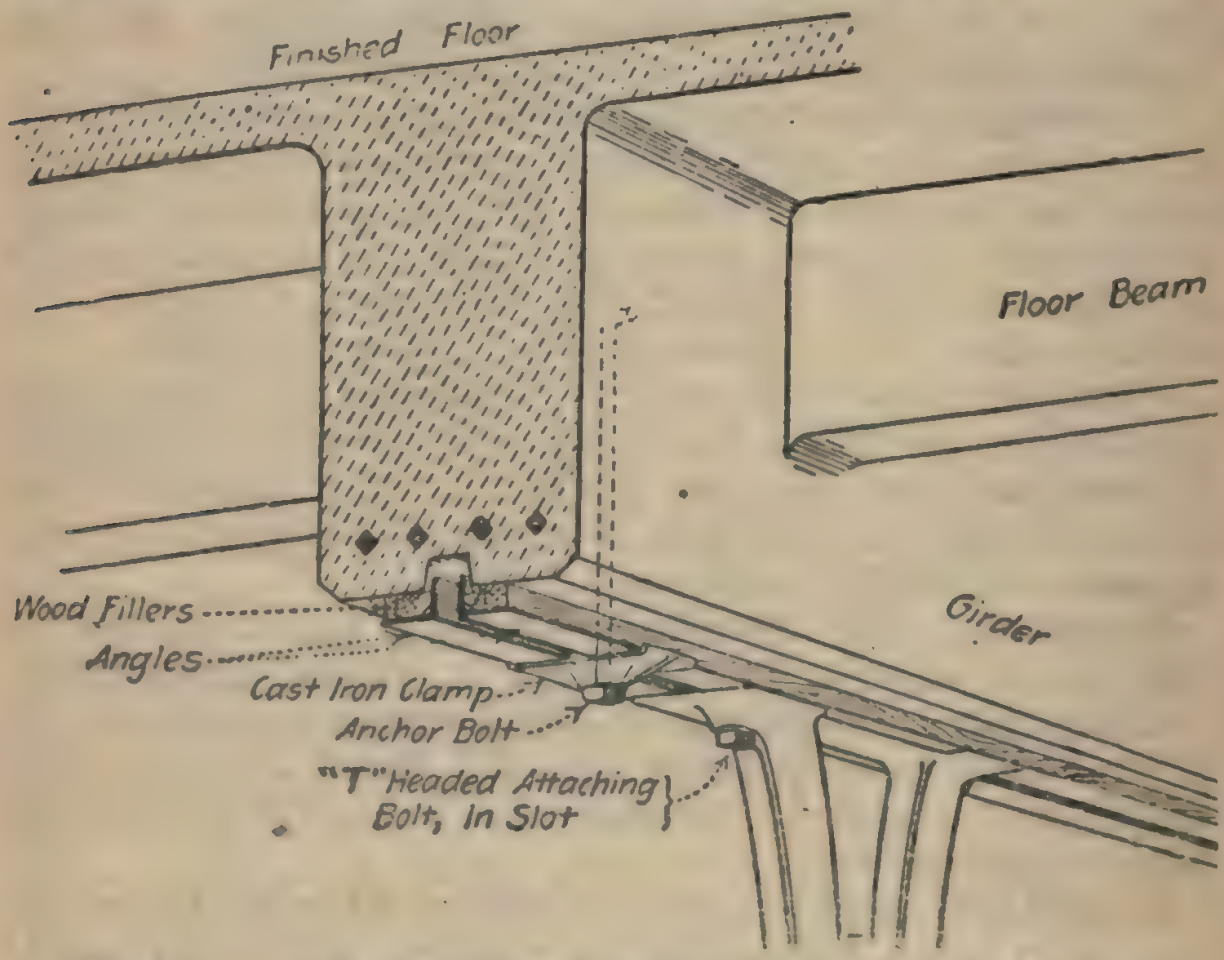


FIG. 29.—ONE METHOD OF PROVIDING FOR SHAFT HANGERS.

Shaft Hangers.—In factory buildings it is necessary to hang shafting for machinery. This must be adjustable to accommodate changes and improvements in the apparatus. Fig. 29 shows methods of using slotted pipes for this purpose which have been endorsed by use.

Signals.—Use well understood signals, (a steam whistle is best), to keep the material coming up to the mixer.

A whistle blown 5 or 10 minutes before starting

work, serves as a warning and helps to get the men started on time.

Slide Rule.—We cannot too strongly recommend the use of a slide rule for calculations on construction work. The way in which the intelligent use of this little instrument saves time and secures results is wonderful, and we believe that every man in the field who is called upon to any extent to estimate quantities or cost should own and know how to use one. The book of instructions which comes with the rule is plain enough.

A mechanic with a pair of overalls on, has a pocket in which to put his rule and pencil. With this idea and with a resentment toward being handicapped either in office or field by lack of pockets (especially in summer when no vests are worn) an acquaintance some time ago had the tailor put narrow side pockets in front of the seams in his trousers—one on the left, just fitted for a 10-in. slide rule. and one on the right, a tight slip pocket modeled to hold 2 or 3 pencils or a fountain pen. It is a great convenience to have a pencil and slide rule where you can put your hand on them. These, together with a ring loose-leaf book in the hip pocket, make an ideal outfit for a field man.

Stationery.—Do not under any conditions allow the field or office force to use blank forms for scrap paper. It is a wasteful and dangerous practice.

Steady Men.—There are always several men on the payroll who through efficiency or long service, merit steady time and who should not lose time on account of rain or other circumstances. To keep these men busy during slack or rainy days, it might be well to have a list of work to be done at such time to use as a reminder. Following are suggestions: Repairing wheelbarrows, hods, hose, lockers, tampers, and miscellaneous tools, making horses; cleaning sheds, wheelbarrows (oiling), instruments, steel tapes, mortar from the wall projections, centering (oiling), sharpening

saws, checking material, etc. Make new tool boxes and similarly required staple necessities.

Keep the work cleaned up. Use up scrap centering in the boiler. A rainy day can be used to advantage in cleaning, oiling and sorting the bolts used in the centering, or cutting new wire or straps when these are used. Anticipate the needs of better weather and be prepared.

The superintendent should instruct all his good men, men whom he may want to call upon in an emergency or otherwise, to keep him advised at all times of their correct address. Get their phone numbers if possible.

Surface Finish.—There are several methods to choose from in general use which are about as follows:

Remove the centering while the concrete is green and wash off the cement surface, using wire brushes. Beautiful effects can be secured by using beach pebbles, differently colored granites, etc.

If the concrete is set too hard for the above, use a dilute solution of hydrochloric or sulphuric acid to cut away the skin coat of sand and neat cement. Wet the concrete thoroughly before applying acid.

Rub down with pieces of stone, and brush with cement and water or a thin cement mortar.

Surfaces can be hand or pneumatic hammered with good results. Any kind of tooled surface can be secured with suitable aggregate. Sand blasting has also been used with success.

A "splatter" finish has been used extensively in Europe, consisting essentially of a "dash" coat of "sloppy" mortar.

Whitewashing, plastering, cold water paints, are used considerably. On fairly large work, compressed air spraying machines are an economy.

The most artistic finish is undoubtedly a tooled or acid finish. In this, the superficial coat of neat cement and sand is removed and we see concrete in its un-

covered strength. Plastered and cement-painted surfaces only use more superficial coating, increasing the opportunity for hair cracks and craing.

The most important point of all is to have the entire surface of an even color and uniform appearance. Care in selection of materials and the same crew of mechanics with constant supervision will secure this.

TABLE OF LINEAR MEASURES.

(M. M.)	(C. M.)	
10 millimeters	=1 centimeter	= 0.3937 in.
10 centimeters	=1 decimeter	= 3.937 in.
10 decimeters	=1 meter	= 39.37 in.
10 meters	=1 dekameter	=393.37 in.
10 dekameters	=1 hectometer	=328.00 ft. 1 in.
10 hectometers	=1 kilometer	= 0.62137 miles.
	(k. m.)	
10 kilometers	=1 myriameter	= 6.2137 miles.

The meter is used in general, the centimeter or millimeter in reckoning short distances, and the kilometer for long distances.

A centimeter is about $\frac{3}{8}$ of an inch.
A meter is about 3 ft. $3\frac{3}{8}$ in.
A kilometer is about 200 rods, or $\frac{5}{8}$ of a mile.

Temporary Closet.—It is only fair to the men to provide a clean closet. Keep a can of chloride of lime in this building and use frequently. This comes in handy pound cans and is commercially known as "Bleaching Powder."

Telephones.—Telephones are of great use in construction work. The instrument should be placed in a position where the user can see as much of the work as possible.

Wall Ties.—On concrete walls that require brick facing, provide metal ties to bond the brick veneer to the concrete. Any one of the metal ties will fit in between the centering boards. When steel straps or wires are used to hold in the centering, these provide additional bond.

Washing Aggregate.—The mixer can be used for washing dirty sand or gravel. Put a load in the ma-

chine and run the hose in. Keep the mixer and hose running and the water will overflow, carrying the loam with it.

Waterproofing is done in many ways but it is now quite generally recognized that a concrete impervious to water may be obtained by very careful grading of the aggregate, and use of a rich mixture. As rich mixtures are nearly always used in reinforced concrete work in order to obtain necessary strength and adhesion to the bars, it would seem that by the use of a properly graded aggregate, impervious concrete might always be obtained. In practice, however, it is seldom practicable to obtain such ideal aggregate and very often it is advisable to waterproof. There have recently been placed upon the market a large number of prepared substances for waterproofing concrete by mixing with the concrete. These substances give good results.

Weight of Materials.—The following data will be of use in making a rough check on quantities:

Granite ..... measures 12 cu. ft. to the ton.
Crushed Granite .....measures 20 cu. ft. to the ton.
Broken Stone ..... measures 20 cu. ft. to the ton.
Sand ..... measures 20 cu. ft. to the ton.
Coal (soft, broken) ....measures 40 cu. ft. to the ton.

Weight of Cast Iron.—To find the weight of cast iron plates: Multiply the length in inches by the width in inches by the thickness in inches and divide by 4. The result will be the weight of the plates in pounds.

CONCRETE INSPECTION.

Inspection work can be separated into two classes, but the duties of each class are the same, the difference lying mainly in the fact that in the one case the inspector reports to the concern for whom the work is done and in the other he reports to the concern doing the work. In may cases the duties of the inspector are performed by those who have other duties assigned

to them. This is, necessarily, the case upon small jobs, while on the large and important works there may be a number of inspectors among whom the different classes of work are divided. A satisfactory inspection cannot be made by an unskilled man, the duties of the position demanding one who has more than a superficial knowledge of the line of work and preferably a certain amount of engineering knowledge. The most essential qualification for the position is good, sound common sense coupled with an ability to keep the temper under strict control. Circumstances continually arise in this line of work which are aggravating and apt to lead to hasty speech. It is desirable that the inspector be able to keep his self control in such emergencies. It is necessary that the superintendent of construction, each inspector and the foremen of the various lines of work should understand the position and authority of the inspector. The resident engineer and the superintendent must be familiar with the duties of the inspector. Where possible, it is desirable that the duties of the inspector should be definitely outlined; it is, however, impossible to lay down a series of rules and regulations which will cover all possible contingencies, and common sense must be used in dealing with emergencies, in interpreting the rules and specifications governing the inspection of the work and materials and in interpreting the various clauses in the contract and the specifications under which the work is being conducted.

Duties of the Inspector.—It is the duty of the inspector to familiarize himself with the terms of the specifications and such clauses of the contract as have a bearing upon the methods of conducting the work. He must also be familiar with the drawings and other plans conncerning the work in hand. It is necessary that an inspector should be on the work during the entire time it is in progress, during the erection of forms, the placing of reinforcement, the mixing and

placing of the concrete and the removal of the forms and the finishing of the work. The inspector represents the resident engineer or the superintendent of construction and is responsible for the correct, detail performance of the work and of the duties assigned to him.

On large works there will be several inspectors, each assigned to certain specific portions of the work. Each inspector must carefully and continuously watch the progress of the work under his supervision and keep such records of the amount of work performed, the number of foremen and laborers, etc., engaged, the condition of the weather, temperature and the direction of the wind, as he may be directed to make by his superior. He must particularly note the manner in which the work is done and whether it conforms to the specifications, contract, etc. In many cases the inspector may be required to fill out these reports upon blank forms provided for the purpose; while in other cases no special blanks will be provided, but he will be furnished with a note book for keeping these records. One method or the other should be used. The inspector in charge of the mixing should keep a record of the number of batches of concrete mixed, and variations in the proportions of the ingredients and the reason, the character of the mixture and the arrival and quantity of materials received, together with such other data as he may be directed to gather.

Specifications.—A copy of the specifications must be kept on the work and the inspector must be posted on those portions which govern the work under his supervision, and which explain his relationship and the authority which is delegated to him.

Authority of the Inspector.—The inspector is expressly forbidden to give any directions, either verbal or written, to the contractor except over the signature of the engineer. He will immediately report anything which may, in his judgment, be desirable to bring to

the attention of the engineer. It is, however, desirable to avoid all friction and conflict of authority on the work, and in the interpretation of these instructions the inspector must use common sense.

Drawings.—The drawings should be carefully studied and their correctness verified. Any inconsistencies or errors should be, at once, reported to the engineer, and no work should be permitted when there is any doubt in regard to the accuracy of the plans for it. In these cases the engineer or the inspector should communicate by telephone or telegraph with some one having authority to verify the matter.

Communications.—Where possible all communications of importance should be transmitted in writing, the inspector retaining a copy. Telegrams and telephone messages should be duly confirmed in writing.

Cement.—The receipt of each shipment of cement must be noted and its correspondence with the report of the mill tests must be checked by a count of the number of bags or barrels, the presence of the laboratory inspection tags, brands and the car initials and numbers. Broken packages must be put to one side.

Sampling.—The method of sampling must be that directed by the specifications, when there embodied. Careful and accurate sampling is necessary in order to obtain a true average of the shipment for the check analysis. A sample should be taken from each barrel or every fourth sack by a sampling rod which will reach to the bottom of the bag or barrel, in small shipments; for large shipments every tenth barrel should be sampled and the samples representing 50 barrels shall be combined. If it is inconvenient to sample the bags during the work of unloading, one bag in every 40 should be set aside for sampling later. Each sack for the sample pile must be tagged with the car number and initials so that it can be positively identified with the shipment it represents.

Storage.—Cement must be stored under a weatherproof cover on a platform raised a sufficient height above the ground to prevent any dampness reaching the cement. Only unbroken packages will be stored. Broken packages must be put to one side during the work of unloading, until the count of the car can be verified. If undamaged, they will be used as promptly as possible.

Sand.—The sand should be clean and coarse. The cleaner the better. Fine sand should be avoided; it is difficult to mix evenly and this may lead to poor results. If the sand is too coarse, it is not of the best quality, but it is not as likely to cause trouble as a fine sand.

A rough test for cleanliness of the sand is to rub it between the hands; it will not soil them if it is clean. A more accurate method is to put a sample of the sand in a bottle, fill it with water nearly to the top, then shake the bottle thoroughly. The sand will settle to the bottom with the dirt on top of it when the mixture is allowed to settle. The amount of dirt can be measured approximately. Sand containing 5 per cent or more of foreign matter should be rejected.

In sampling the sand, care should be used to obtain an average sample.

Gravel.—Gravel is not to be used, except when special permission is obtained. It must conform to the specifications and be screened when it contains a large percentage of sand, or the amount of sand used in mixing the concrete must be reduced. The amount of sand in the gravel can be estimated by sifting samples of it.

Broken Stone.—Broken trap rock forms a desirable aggregate. *Limestone must be avoided in work exposed to high temperatures.* Stone must comply with the specifications in regard to size. Each lot of stone must be inspected to see that it does not contain quantities of stone dust. Many quarries prefer to de-

liver run of crusher stone; such stone is irregular and full of dust. Screened stone should be insisted upon.

The size of stone should be proportioned to the size of the members in which the concrete is to be placed. In columns, slabs and small beams the maximum size of the stone should not run over ¾ in. and the minimum size should be approximately ⅛ in. In members of larger proportions 1¼-in. stone may be used and in massive work 2-in. stone may be used and where permitted rubble stone can be embedded in the concrete.

Steel.—Steel must comply with the specifications. This applies equally to plain reinforcing rods and built-up members. Each shipment, as it is received should be checked over with the bills, assorted and stored so that it can be got at as needed; each portion being so placed that the material needed first can be got at without rehandling. This point is important. The absence of marks on built-up members should be reported promptly and such pieces should be laid aside, if possible, so they can be marked upon receipt of definite information.

A thin film of rust on the steel is not objectionable. Loose or scaly rust must be removed by the use of a stiff wire brush.

Steel must be free from oil or paint which will lessen the adhesion of the concrete.

The steel must be so braced and supported that the placing of the concrete will not force it out of position.

The sizes and amount of reinforcing required for each member is designated upon the drawings and the inspector must see that this reinforcement is placed in position correctly. No concrete must be placed until the inspector has satisfied himself, by personal inspection, that this has been done. This inspection must be made immediately before the concrete is placed.

Where bars are left protruding they should be protected from rusting by a coat of neat cement grout.

In bending the bars the force must be gradually ap-

plied. All bending ought to be done cold and each bend must be inspected for cracks. Cracked bars must be replaced. When any bars are broken they must be replaced.

Splices in the reinforcement must be made where indicated upon the drawings and must break joints as far as possible.

In spacing the bars, in slabs or columns, templets should be used to make certain that all connections will fit accurately.

In columns it is necessary to leave one side of the form open until the steel has been properly located.

Column splices should be made as directed as on detail drawings, care being used to see that full bearing is obtained. Four or more bars should be used per column and the bars must be securely wired together at regular intervals, in such a manner that the reinforcing cannot shift while the concrete is being placed.

All steel must be placed so that there will be at least 1½ in. of concrete between it and the form.

All hooping and other ties must be a tight fit.

Where extra splice bars are required care must be used to see that they are not omitted.

In beams and slabs considerable care must be used to see that no reinforcement comes closer than 1½ in. from the form and that the reinforcement is in accordance with the plans.

Should any discrepancy be noted in regard to the reinforcement of similar members, it should be brought to the attention of the engineer.

The proper reinforcement of the members is of the highest importance and nothing can be permitted to interfere with it.

Precautions.—After forms and false work have been erected they should be protected from damage by the elements. Immediately before the placing of the concrete the forms and false work should be inspected.

This is particularly necessary when the forms have stood empty for any time. Care should be used to see that the bracing and supports are tight and that the joints are close. No concrete should be placed until the forms have been made tight. In warm weather the forms should be thoroughly wet down before placing the concrete. This will prevent the dry lumber extracting the water from the surface of the concrete.

Forms.—All forms must be true and out of wind and rigid. If to be handled as a unit temporary bracing must be applied to prevent their being strained in handling and erection. The bracing must be such that bulging cannot occur. Winds, twists and bulges impair the appearance of the work and their removal is often expensive. These defects can be prevented by well set, properly built forms. The joints in forms must be tight enough to prevent the leakage of the liquid mass, as such leakage causes a poor surface.

Slab forms or centers must be arranged so that they can be removed without disturbing the supports below the beams. Column forms should also conform to this condition. The sides of the beam forms can then be removed and the false work left under the beams until the heavier mass of concrete has been afforded ample time to set. Bevel strips should be used in the forms so that sharp corners are avoided.

Bracing.—All forms, centering, etc., must be braced in at least two directions. Especial care should be taken to see that the false work is thoroughly braced to withstand any heavy wind storms, etc.

False Work.—Care should be used to see that all posts and braces supporting the forms have a solid footing. Bearers should be used to avoid concentrated loads on slabs or on soft material, particular care being taken to see that the load is so thoroughly distributed that there is no danger of settlement occurring. Double wedges should be used under the feet of all braces and

posts. This will permit setting the work up tight and its removal without damage to the green concrete.

Cleaning Out of Forms.—All forms must be thoroughly cleaned out before any concrete is placed. The inspector must be absolutely certain from personal inspection that all foreign material has been removed from the forms. Particular care must be taken to see that sawdust and shavings are washed out from all places in which they may have collected and that they are removed from the form. In column forms an opening must be left at the bottom for cleaning. This opening must not be closed until concrete is ready.

Labor.—It is desirable that skilled labor be employed on form work and competent foremen are necessary. One man in each gang must be in charge of it, under the head carpenter or general foreman.

Removal of Forms and False Work.—The forms and false work must be removed with care. IMPACT STRESSES ARE DANGEROUS. EVEN A MODERATE WEIGHT WHEN FALLING CAN CAUSE SERIOUS DAMAGE. All forms must be eased down and not allowed to drop. Knocking out of the posts and letting everything fall must not be tolerated under any circumstances. In many cases where reinforced concrete buildings have collapsed, with attendant serious damage and loss of life, the accidents have been caused by the improper removal of the forms and false work. Smashing the forms out is very nearly as dangerous as premature removal.

The men engaged in the removal of the forms and false work should be very carefully instructed in the danger and the disastrous results caused by carelessness, which will be liable to subject them to imprisonment. In the case of an accident they will be held for trial on the charge of criminal negligence.

The forms should not be removed if there is any load on a panel beside its own weight.

The removal of the forms and false work will reveal any weak points that may exist.

The approval of the engineer or of the architect must be obtained before the removal of the false work is commenced. Test cubes must be consulted in order to determine the condition of the concrete prior to the removal of the forms.

Warm, dry weather is the most favorable for the rapid setting of concrete. Cool, damp weather retards the setting of concrete, and in very hot weather it must be wetted to prevent rapid setting. In cold weather the greatest amount of care should be used. More time will be saved by being careful than by rushing matters and having an accident.

Frozen Concrete.—Concrete will not set while frozen and it is difficult, if not impossible, to judge the condition of frozen concrete. False-work must never be removed while the concrete is frozen. Frozen concrete can be thawed out by artificial heat, if necessary, and its set and hardness can then be determined. Great care is necessary in order to be absolutely certain that the concrete is thoroughly thawed out.

It is impossible to give any certain rule in regard to the length of time which must be permitted to elapse before the removal of the false work and forms is commenced. The removal of the forms should not be begun until the concrete is thoroughly set. The inspector must personally satisfy himself in regard to the condition of the concrete, which must be hard and should ring when struck with a hammer.

Column forms should be left in position for at least seven days, under favorable conditions. Upon their removal the column should be carefully inspected and its soundness approved.

The exposure of the surface to the air facilitates the setting of concrete. It is not good for the surfaces, however.

The wedges under the posts supporting the slab

forms should be loosened after not less than two weeks, to a sufficient extent to permit the form to drop away from the slab for an inch or two. The false work must be left in this condition for at least twenty-four hours. The slab should be carefully inspected while the wedges are being loosened. At the end of the twenty-four hours the posts and joists can be carefully removed and the form taken down. The side forms of beams and girders should be removed at the same time as the slab forms, but the shoring beneath them must be left in place.

Immediately after the removal of the slab forms, the slabs should be shored up. These shores should be left in position for at least one week. If the floor slab may be called upon to support any load except its own weight these shores must be left in position as long as the possibility of such loading exists.

The forms and false work supporting beams or girders must be left in place at least three weeks. In removing these supports the wedges must be loosened very carefully. If the beam is liable to receive any load at this period the shores should be left in position for at least a week or two more.

Concrete—Water.—The water must be fresh and clean, free from all earth, dirt and sewage or other impurities liable to injure the character of the concrete or mortar. Acids or alkalies are injurious.

Proportions.—The proportions given in the specifications must be adhered to, and some measuring device must be used which will insure accurate proportioning of the various materials.

Mixing.—Machine mixed concrete is preferred. The aggregate for each batch must be first mixed dry until it is uniform, then the water must be added while the mixing is continued. Some mark must be placed on the mixer so that the number of turns of the mixer can be counted. The time required for each operation should also be checked, in order to obtain uniform re-

sults. A wet or slushy mixture must be made. The color of each batch must be carefully noted as it comes from the mixer. Uniformity of color must be insisted upon. The mixer must be in charge of a foreman.

The operations of placing the materials in the mixer must be carefully checked and it is advisable that one inspector be especially detailed for this work. The laborers placing the materials in the mixer must be selected for their intelligence and ability to understand the directions given them.

Freezing Weather.—Work must be suspended during freezing weather, except by permission of the engineer. When concrete is to be placed during freezing weather salt must be used in the water if deemed necessary, the water, sand and broken stone may also be heated.

Foundations and heavy walls, where the face appearance is of no consequence, may be run in freezing weather; but great care should be exercised in order to prevent the concrete freezing, by heating the materials and protecting the work. Frozen concrete must be torn out and rebuilt.

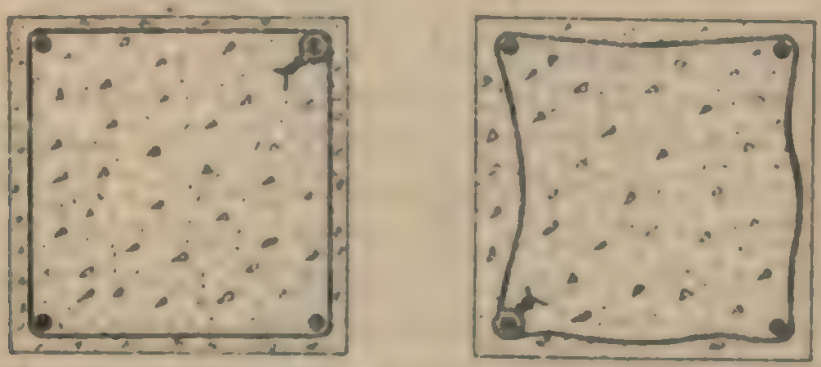


FIG. 31.—CORRECT AND INCORRECT METHOD OF SETTING COLUMN HOOPS.

Hot Weather.—During hot weather the sand and broken stone become heated by the sun, sometimes to such an extent that they tend to cause the cement to set in the mixer. In hot weather the stone must always be thoroughly wet down before it is used. If

necessary the sand and stone piles must be protected from the sun.

Placing Concrete.—No concrete must be placed in any form unless the inspector has personally assured himself that the form has been cleaned out and the abutting surfaces of concrete have been properly prepared to make a bond with the new work. Be sure also that no foreign substances have become lodged in any portion of the form or reinforcement.

Each batch of concrete must be in place within twenty minutes from the time it is discharged from the mixer.

Concrete must not be deposited in any portion of the work until all of the reinforcement for that part of the work are in position and have been checked over to see that they agree with the drawings. The steel work must be kept sufficiently ahead of the concrete work to give ample time for inspection.

No lumps of concrete must be permitted to lie in any of the cars, hoppers, troughs, wheelbarrows, or other receptacles which are used for conveying it from the mixer to the form. Each receptacle must be cleaned at the cessation of work.

The concrete inspector must note carefully the uniformity of the mixture delivered to the forms and see that it contains no foreign substances. He should be careful to note whether the color apparently indicates the proper mixture and in cases of doubt must verify from the mixer the proportions of the batch.

Each beam and slab must be completed monolithically. No portion of the work must be started unless it can be pushed to completion, except by special permission of the engineer.

In filling the forms, care must be used to spade the stones back so that a mortar finish will be secured. If called for in the specifications facing mortar must be deposited simultaneously with the concrete. The facing mortar can be held in position until the backing of

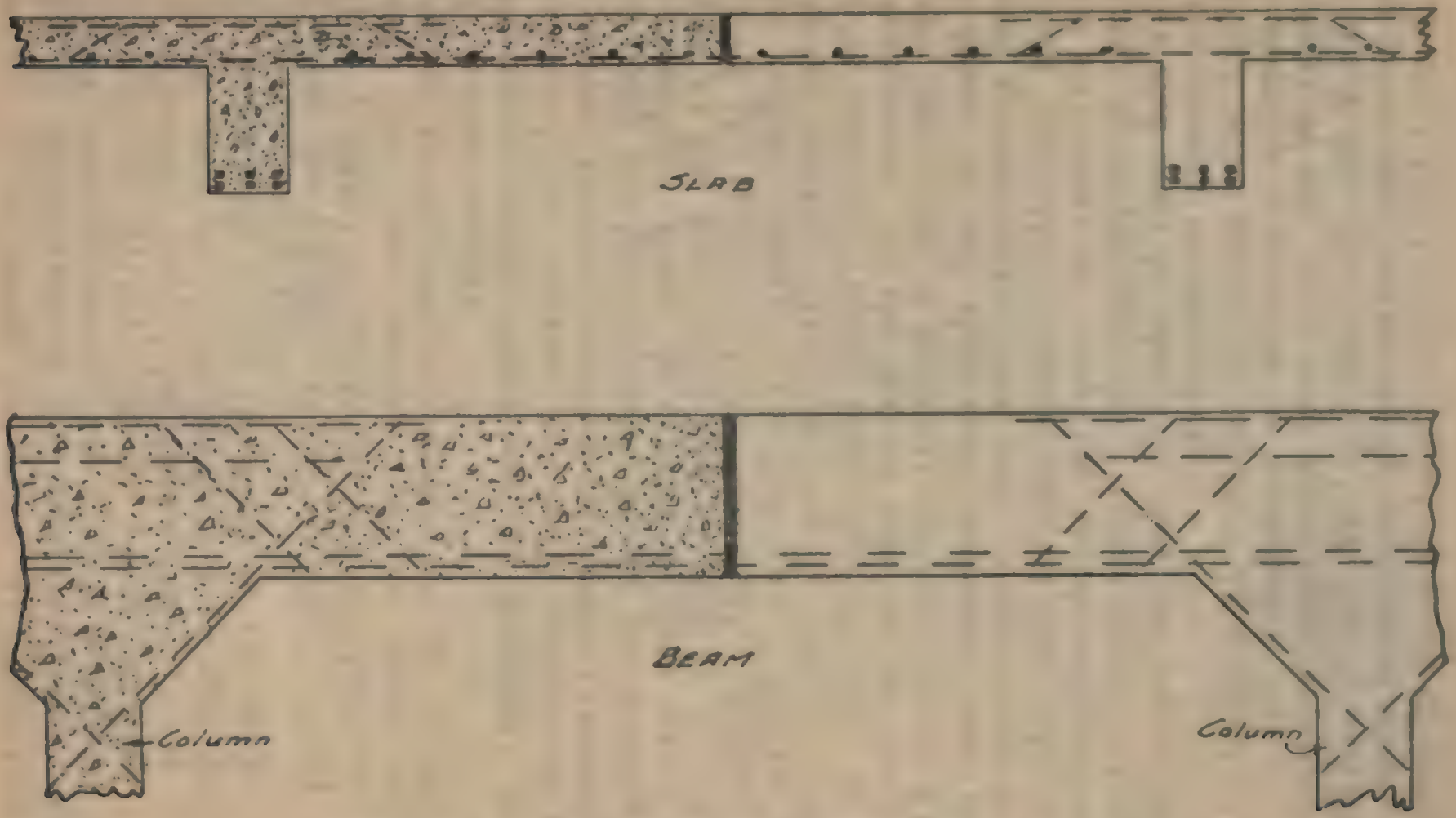


FIG. 30.—SAFE POINTS TO STOP CONCRETING.

concrete is deposited by means of sheet iron which must be withdrawn as the concrete is deposited.

Work must be carried on in such a manner that the workmen can be kept off the green concrete. Persistent offenders should be discharged.

Work must not be stopped on a column until it has been brough up to the elevation of the lower surface. of the connecting beams.

During the placing of the concrete it must be constantly puddled to work out the air bubbles. Occasionally the lower portion and the upper portion of columns, for from two to three feet, are poured with a rich cement mortar.

Points at which Work can be Stopped.—After the placing of the concrete has been commenced it must be carried forward continuously until a suitable stopping point has been reached. Beams and girders should be completed from the center of one panel to the center of the next panel and carried up to the elevation of the bottom of the floor slab. Some carry it from column center to column center; but the former is better practice. If work is to be stopped before the slab is concreted extra reinforcement must be placed to compensate for the loss of area due to the omission of the floor slab. Additional ties shall be used to bind the beam to the slab and continuity bars must be placed at each end of the beam to tie it into the beam coming upon the opposite side of the column. The floor slab must be completed simultaneously with the beams. In stopping work on a monolithic floor slab the entire slab must be placed so that the break will come at the centers of the panel.

Work must always be stopped at a point at which the shearing stresses are a minimum.

Night Work.—It is sometimes necessary to continue the work into the night in order that a suitable stopping point may be reached by continuous work. Night work must not be done except in cases of emergency.

During the progress of night work it is necessary to be extremely careful to see that the work is carried on in exact accordance with the specifications. No night work will be permitted unless proper arrangements are made for the lighting of the work.

Records.—The date upon which each portion of the work is completed must be marked in ink upon the plans. This entry must not be neglected, it must be made each day immediately after the completion of the work.

Test Pieces.—A test cube, in the case of slabs 6x6x6 in. and in the case of beams 12x12x12 in. must be made each day. Each cube must be dated. These cubes will be poured in boxes and will be used to approximately determine the condition of the work before the centering is removed. Care must be used to see that each cube is exposed to conditions approximating the exposure of the portion of the work to which it refers.

Cement Finish.—When the cement finish is less than 3 in. thick it must be deposited, practically simultaneously with the concrete. The finish must conform to the specifications and the drawings.

Cutting out Concrete.—Cutting holes in the concrete will not be permitted except by the permission in writing of the engineer. The location of each cut must be clearly indicated. Beams must not be cut under any consideration.

Caution.—The engineer or his duly authorized representative, alone have any authority to give directions in regard to the work. Any directions involving the slightest departure from the plans or specification or from both must be given in writing. Particular care must be used to follow this direction. No man upon the work is to be permitted to receive any orders whatsoever, except from those placed directly in authority over him.

Typical Analysis of Cements—(*Taylor & Thompson.*)

	Portland cement		Natural Cement							Common Lime	
			American		Eng.	French					
	Lehigh Valley (mixed rock)	Western (marl and clay)	Eastern Rosendale	Western Louisville	Roman	Vassy	Grappiers	Puzzolan Cement	Hydraulic Lime (Le Tiel)	Lime	Magnesian Lime
Silica $Si O_2$	21.31	21.93	18.38	20.42	25.48	22.60	26.5	28.95	21.70	1.03	1.12
Alumina $Al_2 O_3$	6.89	5.98	15.20	4.76	10.30	8.90	2.5	11.40	3.19	1.27	0.68
Iron Oxide $Fe_2 O_3$	2.53	2.35		3.40	7.44	5.30	1.5	0.54	0.66		
Calcium Oxide Ca O	62.89	62.92	35.84	46.64	44.54	52.69	63.0	50.29	60.70	97.02	58.51
Magnesian Ox. Mg O	2.64	1.10	14.02	12.00	2.92	1.15	1.0	2.96	0.85	0.68	39.69
Sulphuric Acid $S O_3$	1.34	1.54	0.93	2.57	2.61	3.25	0.5	1.37	0.60		
Loss on Ignition	1.39	2.91	3.73	6.75	3.68	6.11	5.0	3.39	12.20		
Other constituents	0.75		11.46	3.74	1.46			0.30	0.10		

+ LUMBER MEASURE +

Size	Length in Feet					
	10	12	14	16	18	20
1×4	3⅓	4	4⅔	5⅓	6	6⅔
1×6	5	6	7	8	9	10
1×8	6⅔	8	9⅓	10⅔	12	13⅓
1×10	8⅓	10	11⅔	13⅓	15	16⅔
1×12	10	12	14	16	18	20
2×4	6⅔	8	9⅓	10⅔	12	13⅓
2×6	10	12	14	16	18	20
2×8	13⅓	16	18⅔	21⅓	24	26⅔
2×10	16⅔	20	23⅓	26⅔	30	33⅓
2×12	20	24	28	32	36	40
4×4	13⅓	16	18⅔	21⅓	24	26⅔
4×6	20	24	28	32	36	40
4×8	26⅔	32	37⅓	42⅔	48	53⅓
4×10	33⅓	40	46⅔	53⅓	60	66⅔
4×12	40	48	56	64	72	80
6×6	30	36	42	48	54	60
6×8	40	48	56	64	72	80
6×10	50	60	70	80	90	100
6×12	60	72	84	96	108	120
8×8	53⅓	64	74⅔	85⅓	96	106⅔
10×10	83⅓	100	116⅔	133⅓	150	166⅔
12×12	120	144	168	192	216	240

SAFE LOADS for POSTS and BRACES. (Common Pine)

Length in Feet	Sizes in Inches								
	2×4	2×6	2×8	3×4	4×4	4×6	6×6	6×8	8×8
	Load in Pounds								
1	------	------	------	------	------	------	------	-----	------
2	4,800	7,200	9,600	-----	-----	-----	-----	------	------
3	4,136	5,904	8,272	7,200	-----	------	------	------	------
4	3,648	5,472	7,296	6,048	9,600	14,400	------	------	------
5	3,360	5,040	6,720	5,760	8,160	12,240	------	------	------
6	3,072	4,608	6,144	5,472	7,872	11,808	21,000	28,800	------
7	2,784	4,176	5,568	5,184	7,584	11,376	18,576	24,768	------
8	2,496	3,744	4,992	4,896	7,296	10,944	18,144	24,192	------
9	2,208	3,312	4,416	4,608	7,008	10,512	17,712	23,616	38,400
10	1,920	2,880	3,840	4,320	6,720	10,080	17,280	23,040	33,280
11	1,632	2,448	3,264	4,032	6,432	9,648	16,848	22,464	32,768
12	1,344	2,016	2,688	3,744	6,144	9,216	16,416	21,888	32,256
13	1,056	1,584	2,112	3,456	5,856	8,784	15,984	21,312	31,744
14	768	1,152	1,536	3,168	5,568	8,352	15,552	20,736	31,232
15	480	720	960	2,880	5,280	7,920	15,120	20,160	30,720
16	192	288	384	2,592	4,992	7,488	14,688	19,584	30,208
17	------	-----	------	2,304	4,704	7,056	14,256	19,008	29,696
18	------	------	------	2,016	4,416	6,624	13,824	18,432	29,184
19	------	------	------	1,728	4,128	6,192	13,392	17,856	28,672
20	------	-----	------	1,440	3,840	5,760	12,960	17,280	28,160
21	-----	------	------	1,152	3,552	5,328	12,528	16,704	27,648
22	-----	-----	------	864	3,264	4,896	12,096	16,128	27,136
23	------	------	------	576	2,976	4,464	11,664	15,552	26,624
24	------	------	------	288	2,688	4,032	11,232	14,976	26,112
25	------	------	------	------	2,400	3,600	10,800	14,400	25,600
26	------	------	------	------	2,112	3,168	10,368	13,824	25,088
27	-----	------	------	------	1,824	2,736	9,936	13,248	24,576
28	------	-----	------	------	1,536	2,304	9,504	12,672	24,064

Differential for Size.

3/16"	rods	$1.00	extra	per	hundred	lbs.
1/4"	"	.35	"	"	"	"
5/16"	"	.30	"	"	"	"
3/8"	"	.25	"	"	"	"
7/16"	"	.20	"	"	"	"
1/2"	"	10	"	"	"	"
9/16"	"					
5/8"	"	05	"	"	"	"
11/16"	"					
3/4" to 3"	rods	Base				

SPIKES AND NAILS

Sizes	Length Inches	Standard Steel Wire Nails — Common: Diam. Inches	Common: No. per pound	Finishing: Diam. Inches	Finishing: No. per Pound	Steel Wire Spikes: Length Inches	Steel Wire Spikes: Diam. Inches	Steel Wire Spikes: No. per Pound
2d	1	.0524	1060	.0453	1558	3	.1620	41
3d	1¼	.0588	640	.0508	913	3½	.1819	30
4d	1½	.0720	380	.0508	761	4	.2043	23
5d	1¾	.0764	275	.0571	500	4½	.2294	17
6d	2	.0808	210	.0641	350	5	.2576	13
7d	2¼	.0858	160	.0641	315	5½	.2893	11
8d	2½	.0935	115	.0720	214	6	.2893	10
9d	2¾	.0963	93	.0720	195	6½	.2249	7½
10d	3	.1082	77	.0808	137	7	.2249	7
12d	3¼	.1144	60	.0808	127	8	.3648	5
16d	3½	.1285	48	.0907	90	9	.3648	4½
20d	4	.1620	31	.1019	62	....	....	....
30d	4½	.1819	22	....	....	....	....	....
40d	5	.2043	17	....	....	....	....	....
50d	5½	.2294	13	....	....	....	....	....
60d	6	.2576	11	....	....	....	....	....

+ PROPERTIES of PLAIN STEEL RODS +

Square Rods			Size	Round Rods		
Perimeter	Weight per lin. ft.	Sectional Area		Sectional Area	Weight per lin. ft.	Circumference.
1.00 in.	.2121 lb.	.0625 □"	1/4"	.0491 □"	.167 lb.	.785 in.
1.25 "	.333 "	.0977 "	5/16"	.0767 "	.261 "	.982 "
1.50 "	.478 "	.1406 "	3/8"	.1104 "	.375 "	1.178 "
1.75 "	.651 "	.1914 "	7/16"	.1503 "	.511 "	1.37 "
2.00 "	.850 "	.250 "	1/2"	.196 "	.668 "	1.57 "
2.25 "	1.076 "	.316 "	9/16"	.249 "	.845 "	1.76 "
2.50 "	1.328 "	.391 "	5/8"	.307 "	1.044 "	1.96 "
3.00 "	1.913 "	.563 "	3/4"	.442 "	1.502 "	2.36 "
3.50 "	2.603 "	.766 "	7/8"	.601 "	2.044 "	2.75 "
4.00 "	3.400 "	1.000 "	1 "	.785 "	2.670 "	3.14 "
4.50 "	4.303 "	1.266 "	1 1/8"	.994 "	3.379 "	3.53 "
5.00 "	5.312 "	1.563 "	1 1/4"	1.227 "	4.173 "	3.93 "
5.50 "	6.428 "	1.891 "	1 3/8"	1.485 "	5.049 "	4.32 "
6.00 "	7.650 "	2.250 "	1 1/2"	1.767 "	6.008 "	4.71 "

PROPORTIONING · CONCRETE

Proportions of Mixture			Material for 1 Cu Yd Concrete								
			Gravel $\frac{3}{4}$" ϕ under			Stone 1" ϕ under Dust screened out			Stone $2\frac{1}{2}$" ϕ under Dust screened out		
Cement	Sand	Stone	Cem. Bbls.	Sand Yds.	Stone Yds	Cem. Bbls.	Sand Yds.	Stone Yds.	Cem. Bbls.	Sand Yds	Stone Yds
1	2	3	1.54	0.47	0.73	1.70	0.52	0.77	1.73	0.53	0.79
1	2	4	1.34	.41	.81	1.46	.44	.89	1.48	.45	.90
1	2	5	1.17	.36	.89	1.27	.39	.97	1.29	.39	.98
1	$2\frac{1}{2}$	4	1.24	.47	.75	1.35	.52	.82	1.38	.53	.84
1	$2\frac{1}{2}$	5	1.10	.42	.83	1.19	.46	.91	1.21	.46	.92
1	$2\frac{1}{2}$	6	0.98	.37	.89	1.07	.41	.97	1.07	.41	98
1	3	5	1.03	.47	.78	1.11	.51	.85	1.14	.52	.87
1	3	6	0.92	.42	.84	1.01	.46	.92	1.02	.47	.93
1	3	7	0.84	.38	.89	0.91	.42	.97	0.92	.42	.98
1	4	6	0.83	.51	.77	.90	.55	.82	.92	.56	.84
1	4	7	0.77	.47	.81	.83	.51	.89	.84	.51	.90
1	4	8	0.71	.43	.86	.77	.47	.93	.78	.48	.95
1	4	9	0.65	.40	.89	.71	.43	.97	.73	.44	1.01

Mixtures			Required for 1 Cubic Yard Rammed Concrete											
			Stone 1 in. and under, dust screened out			Stone, 2½ in. and under, dust screened out			Stone, 2½ in., with most small stone screened out			Gravel, ¾ in. and under		
Cement,	Sand,	Stone,	Cement, barrels	Sand, cubic yds.	Stone, cubic yds.	Cement, barrels	Sand, cubic yds.	Stone, cubic yds.	Cement, barrels	Sand, cubic yds.	Stone, cubic yds.	Cement, barrels	Sand, cubic yds.	Gravel, cubic yds.
1	1.0	2.0	2.57	0.39	0.78	2.63	0.40	0.80	2.72	0.41	0.83	2.30	0.35	0.74
1	1.0	2.5	2.29	0.35	0.70	2.34	0.36	0.89	2.41	0.37	0.92	2.10	0.32	0.80
1	1.0	3.0	2.06	0.31	0.94	2.10	0.32	0.96	2.16	0.33	0.98	1.89	0.29	0.86
1	1.0	3.5	1.84	0.28	0.98	1.88	0.29	1.00	1.88	0.29	1.05	1.71	0.26	0.91
1	1.5	2.5	2.05	0.47	0.78	2.09	0.48	0.80	2.16	0.49	0.82	1.83	0.42	0.73
1	1.5	3.0	1.85	0.42	0.84	1.90	0.43	0.87	1.96	0.45	0.89	1.71	0.39	0.78
1	1.5	3.5	1.72	0.39	0.91	1.74	0.40	0.93	1.79	0.41	0.96	1.57	0.36	0.83
1	1.5	4.0	1.57	0.36	0.96	1.61	0.37	0.98	1.64	0.38	1.00	1.46	0.33	0.88
1	1.5	4.5	1.43	0.33	0.98	1.46	0.33	1.00	1.51	0.35	1.06	1.34	0.31	0.91
1	2.0	3.0	1.70	0.52	0.77	1.73	0.53	0.79	1.78	0.54	0.81	1.54	0.47	0.73
1	2.0	3.5	1.57	0.48	0.83	1.61	0.49	0.85	1.66	0.50	0.88	1.44	0.44	0.77
1	2.0	4.0	1.46	0.44	0.89	1.48	0.45	0.90	1.53	0.47	0.93	1.34	0.41	0.81
1	2.0	4.5	1.36	0.42	0.93	1.38	0.42	0.95	1.43	0.43	0.98	1.26	0.38	0.86
1	2.0	5.0	1.27	0.39	0.97	1.29	0.39	0.98	1.33	0.39	1.03	1.17	0.36	0.89

1	2.5	3.5	1.45	0.55	0.77	1.48	0.56	0.79	1.51	0.58	0.81	1.32	0.50	0.70
1	2.5	4.0	1.35	0.52	0.82	1.38	0.53	0.84	1.42	0.54	0.87	1.24	0.47	0.75
1	2.5	4.5	1.27	0.48	0.87	1.29	0.49	0.88	1.33	0.51	0.91	1.16	0.44	0.80
1	2.5	5.0	1.19	0.46	0.91	1.21	0.46	0.92	1.26	0.48	0.96	1.10	0.42	0.83
1	2.5	5.5	1.13	0.43	0.94	1.15	0.44	0.96	1.18	0.44	0.99	1.03	0.39	0.86
1	2.5	6.0	1.07	0.41	0.97	1.07	0.41	0.98	1.10	0.41	1.03	0.98	0.37	0.89
1	3.0	4.0	1.26	0.58	0.77	1.28	0.58	0.78	1.32	0.60	0.80	1.15	0.52	0.72
1	3.0	4.5	1.18	0.54	0.81	1.20	0.55	0.82	1.24	0.57	0.85	1.09	0.50	0.75
1	3.0	5.0	1.11	0.51	0.85	1.14	0.52	0.87	1.17	0.54	0.89	1.03	0.47	0.78
1	3.0	5.5	1.06	0.48	0.89	1.07	0.49	0.90	1.11	0.51	0.93	0.97	0.44	0.81
1	3.0	6.0	1.01	0.46	0.92	1.02	0.47	0.93	1.06	0.48	0.97	0.92	0.42	0.84
1	3.0	6.5	0.96	0.44	0.95	0.98	0.44	0.96	1.00	0.45	1.01	0.88	0.40	0.87
1	3.0	7.0	0.91	0.42	0.97	0.92	0.42	0.98	0.94	0.42	1.05	0.84	0.38	0.89
1	3.5	5.0	1.05	0.56	0.80	1.07	0.57	0.82	1.11	0.59	0.85	0.96	0.50	0.76
1	3.5	5.5	1.00	0.53	0.84	1.02	0.54	0.85	1.06	0.56	0.89	0.92	0.48	0.78
1	3.5	6.0	0.95	0.50	0.87	0.97	0.51	0.89	1.00	0.53	0.92	0.88	0.46	0.80
1	3.5	6.5	0.92	0.49	0.91	0.93	0.49	0.92	0.96	0.51	0.95	0.83	0.44	0.82
1	3.5	7.0	0.87	0.47	0.93	0.89	0.47	0.95	0.91	0.49	0.98	0.80	0.43	0.85
1	3.5	7.5	0.84	0.45	0.96	0.86	0.45	0.98	0.86	0.47	1.01	0.76	0.41	0.87
1	3.5	8.0	0.80	0.42	0.97	0.82	0.43	1.01	0.81	0.45	1.04	0.73	0.39	0.89
1	4.0	6.0	0.90	0.55	0.82	0.92	0.56	0.84	0.95	0.58	0.87	0.83	0.51	0.77
1	4.0	6.5	0.87	0.53	0.85	0.88	0.53	0.87	0.91	0.55	0.90	0.80	0.49	0.79
1	4.0	7.0	0.83	0.51	0.89	0.84	0.51	0.90	0.87	0.53	0.93	0.77	0.47	0.81
1	4.0	7.5	0.80	0.49	0.91	0.81	0.50	0.93	0.84	0.51	0.96	0.73	0.44	0.83
1	4.0	8.0	0.77	0.47	0.93	0.78	0.48	0.95	0.81	0.49	0.98	0.71	0.43	0.86
1	4.0	8.5	0.74	0.45	0.95	0.76	0.46	0.98	0.78	0.47	1.01	0.68	0.42	0.88
1	4.0	9.0	0.71	0.43	0.97	0.73	0.44	1.01	0.75	0.45	1.04	0.65	0.40	0.89
1	5.0	9.0	0.66	0.50	0.90	0.67	0.52	0.93	0.70	0.52	0.96	0 61	0.46	0.83
1	5.0	10.0	0.62	0.47	0.95	0.63	0.48	0.96	0.65	0.50	1 00	0.57	0.43	0.87

Wire and Sheet Metal Gauges.—(Cambria Steel Co.)

In Decimals of an Inch.

Number of Gauge	Birmingham or Stubs Iron Wire Gauge	American or Brown & Sharpe Wire Gauge	United States Standard Gauge for Sheet and Plate Iron and Steel	Washburn & Moen Manufacturing Co. and John A. Roebling's Sons Co. Wire Gauge	Trenton Iron Co. Wire Gauge	American Screw Co. Screw Wire Gauge	British Imperial or English Legal Standard Wire Gauge
0000000	....	.....	.5	.....	.....	.....	.500
000000	....	.....	.46875	.4600	.....	.....	.464
00000	....	.....	.4375	.4300	.450	.....	.432
0000	.454	.460000	.40625	.3938	.400	.....	.400
000	.425	.409642	.375	.3625	.360	.0315	.372
00	.380	.364796	.34375	.3310	.330	.0447	.348
0	.340	.324861	.3125	.3065	.305	.0578	.324
1	.300	.289297	.28125	.2830	.285	.0710	.300
2	.284	.257627	.265625	.2625	.265	.0842	.276
3	.259	.229423	.25	.2437	.245	.0973	.252
4	.238	.204309	.234375	.2253	.225	.1105	.232
5	.220	.181940	.21875	.2070	.205	.1236	.212
6	.203	.162023	.203125	.1920	.190	.1368	.192
7	.180	.144285	.1875	.1770	.175	.1500	.176
8	.165	.128490	.171875	.1620	.160	.1631	.160
9	.148	.114423	.15625	.1483	.145	.1763	.144
10	.134	.101497	.140625	.1350	.130	.1894	.128
11	.120	.090742	.125	.1205	.1175	.2026	.116
12	.109	.080808	.109375	.1055	.105	.2158	.104
13	.095	.071962	.09375	.0915	.0925	.2289	.092
14	.083	.064084	.078125	.0800	.0806	.2421	.080
15	.072	.057068	.0703125	.0720	.070	.2552	.072
16	.065	.050821	.0625	.0625	.061	.2684	.064
17	.058	.045257	.05625	.0540	.0525	.2816	.056
18	.049	.040303	.05	.0475	.045	.2947	.048
19	.042	.035890	.04375	.0410	.040	.3079	.040
20	.035	.031961	.0375	.0348	.035	.3210	.036
21	.032	.028462	.034375	.03175	.031	.3342	.032
22	.028	.025346	.03125	.0286	.028	.3474	.028

Wire and Sheet Metal Gauges.—Continued.

In Decimals of an Inch.

Number of Gauge	Birmingham or Stubs Iron Wire Gauge	American or Brown & Sharpe Wire Gauge	United States Standard Gauge for Sheet and Plate Iron and Steel	Washburn & Moen Manufacturing Co. and John A. Roebling's Sons Co. Wire Gauge	Trenton Iron Co. Wire Gauge	American Screw Co. Screw Wire Gauge	British Imperial or English Legal Standard Wire Gauge
23	.025	.022572	.028125	.0258	.025	.3605	.024
24	.022	.020101	.025	.0230	.0225	.3737	.022
25	.020	.017900	.021875	.0204	.020	.3868	.020
26	.018	.015941	.01875	.0181	.018	.4000	.018
27	.016	.014195	.0171875	.0173	.017	.4132	.0164
28	.014	.012641	.015625	.0162	.016	.4263	.0148
29	.013	.011257	.0140625	.0150	.015	.4395	.0136
30	.012	.010025	.0125	.0140	.014	.4526	.0124
31	.010	.008928	.0109375	.0132	.013	.4658	.0116
32	.009	.007950	.01015625	.0128	.012	.4790	.0108
33	.008	.007080	.009375	.0118	.011	.4921	.0100
34	.007	.006305	.00859375	.0104	.010	.5053	.0092
35	.005	.005616	.0078125	.0095	.0095	.5184	.0084
36	.004	.005000	.00703125	.0090	.009	.5316	.0076
37	....	.004453	.006640625	.0085	.0085	.5448	.0068
38	....	.003965	.00625	.0080	.008	.5579	.0060
39	....	.003531	.....	.0075	.0075	.5711	.0052
40	....	.003144	.....	.0070	.007	.5842	.0048

The United States Standard Gauge was legalized by Act of Congress March 3, 1893, as a standard gauge for sheet and plate iron and steel, and is used by the Custom House Department and by about forty-five sheet and tin-plate manufacturers.

Table Showing inches Expressed in Decimals of a foot.

In.	0	1	2	3	4	5	6	7	8	9	10	11
0	Foot	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
1-23	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193
1-16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	8385	.9219
3-32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245
1-8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271
5-32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297
3-16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
7-32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349
1-4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
9-32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401
5-16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
11-32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453
3-8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479
13-32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505
7-16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
15-32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557
1-2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
17-32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609
9-16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
19-32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661
5-8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
21-32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714
11-16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
23-32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766
3-4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	6458	.7292	.8125	.8958	.9792
25-32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818

13-16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
27-32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870
7-8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896
29-32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922
15-16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948
31-32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974
	0	1	2	3	4	5	6	7	8	9	10	11

Effect of Fineness of Sand upon 1 to 2 Cement Mortar.

Size of Sand		Tensile Strength Pounds per Square Inch at the Following Times After Mixing				
Passed Meshes per Lineal inch	Retained Meshes per Lineal inch	After 7 Days	1 Month	3 Months	6 Months	1 Year
4	8	243	442	539	470	668
8	16	269	345	473	512	572
16	20	186	260	313	397	392
20	30	211	281	322	402	440
30	50	149	205	238	275	318
50	75	122	214	260	275	368
75	100	98	153	211	208	253
100	...	98	155	161	229	271

Decimal Equivalents for Fractions of an Inch.

1-32ds	1-64ths	Decimal	Fraction	1-32ds	1-64ths	Decimal	Fraction
	1	.015625			33	.515625	
1	2	.03125		17	34	.53125	
	3	.046875			35	.546875	
2	4	.0625	1-16	18	36	.5625	9-16
	5	.078125			37	.578125	
3	6	.09375		19	38	.59375	
	7	.109375			39	.609375	
4	8	.125	⅛	20	40	.625	⅝
	9	.140625			41	.640625	
5	10	.15625		21	42	.65625	
	11	.171875			43	.671875	
6	12	.1875	3-16	22	44	.6875	11-16
	13	.203125			45	.703125	
7	14	.21875		23	46	.71875	
	15	.234375			47	.734375	
8	16	.25	¼	24	48	.75	¾
	17	.265625			49	.765625	
9	18	.28125		25	50	.78125	
	19	.296875			51	.796875	
10	20	.3125	5-16	26	52	.8125	13-16
	21	.328125			53	.828125	
11	22	.34375		27	54	.84375	
	23	.359375			55	.859375	
12	24	.375	⅜	28	56	.875	⅞
	25	.390625			57	.890625	
13	26	.40625		29	58	.90625	
	27	.421875			59	.921875	
14	28	.4375	7-16	30	60	.9375	15-16
	29	.453125			61	.953125	
15	30	.46875		31	62	.96875	
	31	.484375			63	.984375	
16	32	.5	½	32	64	1.	1

Size of Sheets of Expanded Metal used in Concrete Reinforcement.

Size of Mesh, short way of diamond, inches	Size of Strands, inches	Sec'l. area, per 12 in. width, sq. in.	Max. Stand. length, feet		Max. Stand. width, feet
6	⅜x3-16 bare	0.281			
6	¼x¼ "	0.250	8		16
6	¼x3-16 "	0.187		or	
6	¼x⅛ "	0.125	16		8
6	3-16x⅛ "	0.094			
6	⅛x⅛ "	0.062			
3	½x¼ "	1.000	8		12
3	½x3-16 "	0.750	8	or	11
3	⅜x3-16 "	0.562	12		8
3	¼x¼ "	0.500			
3	5-16x3-16 "	0.469			
3	¼x3-16 "	0.375			
3	5-16x⅛ "	0.312	8		16
3	3-16x3-16 "	0.281		or	
3	¼x⅛ "	0.250	16		8
3	3-16x⅛ "	0.187			
3	⅛x⅛ "	0.125			
3	¼x16 B.S.W.G. bare	0.125			
3	3-16x16 B.S.W.G. "	0.094			
1½	⅜x3-16 bare	1.124	8		8
1½	5-16x3-16 "	0.938			
1½	¼x3-16 "	0.750			
1½	¼x⅛ "	0.500	8		12
1½	3-16x⅛ "	0.375		or	
1½	⅛x⅛ "	0.250	16		8
1½	¼x16 B.S.W.G. bare	0.250			
1½	3-16x16 B.S.W.G "	0.188			
1½	⅛x16 B.S.W.G. "	0.125	8		12
1½	3-32x16 B.S.W. G. "	0.094			
1½	3-32x18 B.S.W.G. "	0.072			

Weights of Merchandise on Wooden Floors.—(Kidder.)

Material	Measurements		Weights		
	Floor space	Cubic feet	Gross	Per sq. ft.	Per cu. ft.
Wool					
Bale East India	3.0	12.0	340	113	28
" Australia	5.8	26.0	385	66	15
" South America	7.0	34.0	1000	143	29
" Oregon	6.9	33.0	482	70	15
" California	7.5	33.0	550	73	17
Bag wool	5.0	30.0	200	40	7
Stack of scoured wool	....	....	....	....	5
Woolen Goods					
Case flannels	5.5	12.7	220	40	17
" flannels, heavy	7.1	15.2	330	46	22
" dress goods	5.5	22.0	460	84	21
" cassimeres	10.5	28.0	550	52	20
" underwear	7.3	21.0	350	48	16
" blankets	10.3	35.0	450	44	13
" horse blankets	4.0	14.0	250	63	18
Cotton, etc.					
Bale	8.1	44.2	515	64	12
" compressed	4.1	21.6	550	134	25
" American Cotton Co	4.0	11.0	263	66	24
" Planters' Compressed Co	2.3	7.2	254	110	35
" jute	2.4	9.9	300	125	30
" jute lashings	2.6	10.5	450	172	43
" manila	3.2	10.9	280	88	26
" hemp	8.7	34.7	700	81	20
" sisal	5.3	17.0	400	75	24
Cotton Goods					
Bale unbleached jeans	4.0	12.5	300	72	24
Piece duck	1.1	2.3	75	68	33
Bale brown sheetings	3.6	10.1	235	65	23
Case bleached sheetings	4 8	11.4	330	69	30
" quilts	7.2	19.0	295	41	16
Bale print cloth	4.0	9.3	175	44	19
Case prints	4.5	13.4	420	93	31
Bale tickings	3.3	8.8	325	99	37
Skeins cotton yarn	....	....	....	....	11
Burlaps	....	....	130	....	30
Jute bagging	1.4	5.3	100	70	24

Weights of Merchandise on Wooden Floors.—Continued.

Material	Measurements		Weights		
	Floor space	Cubic feet	Gross	Per sq. ft	Per cu. ft.
Rags in Bales					
White linen	8.5	39.5	910	107	23
White cotton	9.2	40.0	715	78	18
Brown cotton	7.6	30.0	442	59	15
Paper shavings	7.5	34.0	507	68	15
Sacking	16.0	65.0	450	28	7
Woolen	7.5	30.0	600	80	20
Jute Butts	2.8	11.1	400	143	36
Paper					
Calendered book	....	....	....	....	50
Super calendered book	....	....	....	....	59
News paper	....	....	....	....	38
Straw board	....	....	....	....	33
Leather board	....	....	....	....	59
Writing	....	....	....	....	64
Wrapping	....	....	....	....	10
Manila	....	....	....	....	37
Grain*					
Wheat in bags	4.2	4.2	165	39	39
" in bulk	....	....	....	....	44
" "	....	....	....	....	39
" " mean	....	....	....	....	41
Barrels flour on side	4.1	5.4	218	53	40
" " on end	3.1	7.1	218	70	31
Corn in bags	3.6	3.6	112	31	31
Cornmeal in barrels	3.7	5.9	218	59	37
Oats in bags	3.3	3.6	96	29	27
Bale of hay	5.0	20.0	284	57	14
Hay, Dederick compressed	1.75	5.25	125	72	24
Straw, " "	1.75	5.25	100	57	19
Tow, " "	1.75	5.25	150	86	29
Excelsior, Dederick compressed	1.75	5.25	100	57	19
Hay, loose	....	....	....	....	4

* For pressure of grain in deep bins, see "Engineering News of March 10, 1904, pp. 224 and 336; also of Dec. 15, 1904.

Weights of Merchandise on Wooden Floors.—Continued.

Material	Measurements		Weights		
	Floor space	Cubic feet	Gross	Per sq. ft.	Per cu. ft.
DYESTUFFS, ETC.					
Hogshead bleaching powder	11.8	39.2	1200	102	31
" soda ash	10.8	29.2	1800	167	62
Box indigo	3.0	9.0	385	128	43
" cutch	4.0	8.3	150	38	45
" sumac	1.6	4.1	160	100	39
Caustic soda in iron drum	4.3	6.8	600	140	88
Barrel starch	3.0	10.5	250	83	23
" pearl alum	3.0	10.5	350	117	33
Box extract logwood	1.06	.8	55	52	70
Barrel lime	3.6	4.5	225	63	50
" cement, American	3.8	5.5	325	86	59
" " English	3.8	5.5	400	105	73
" plaster	3.7	6.1	325	88	53
" resin	3.0	9.0	430	143	48
" lard oil	4.3	12.3	422	98	34
Rope	....	....	....	....	42
MISCELLANEOUS					
Box tin	2.7	0.5	139	99	278
" glass	....	....	....	....	60
Crate crockery	9.9	39.6	1600	162	40
Cask crockery	13.4	42 5	600	52	14
Bale leather	7.3	12.2	190	26	16
" goatskins	11.2	16.7	300	27	18
" raw hides	6.0	30.0	400	67	13
" " compressed	6.0	30.0	700	117	23
" sole leather	12.6	8.9	200	22	16
Pile sole leather	....	....	....	....	17
Barrel granulated sugar	3.0	7.5	317	106	42
" brown sugar	3.0	7.5	340	113	45
Cheese	....	....	....	....	30

FOR REFERENCE.

Diameter multiplied by 3.1416 equals circumference.
Circumference multiplied by .3183 equals diameter.
Radius multiplied by 6.2831 equals circumference.
Square of the diameter multiplied by .7854 equals area.
Diameter multiplied by .8862 equals side of equal square.
Area of a rectangle equals length multiplied by breadth.
Doubling the diameter of a circle increases its area four times.
Side of a square multiplied by 1.128 equals diameter of circle of equal area.
Surface of a sphere equals square of diameter multiplied by 3.1416.
Area of a triangle equals base multiplied by one-half the altitude.
Area of a sector of a circle equals one-half the length of the arc multiplied by the radius of the circle.
1 cu. ft. of water weighs 62 1-3 lb. and contains 7½ gals.
1 gal. of water (U. S. Standard) weighs 8 1-3 lb.
To find the capacity (U. S. gallons) of cylindrical tanks, square the diameter expressed in inches, multiply by the length and by .0034.
The pressure of still water in lb. per sq. in. against the sides of any pipe, channel or vessel of any shape whatever is due solely to the "head" or height of the level surface of the water above the point at which the pressure is considered, and is equal to .43302 lb. per sq. in. or 62.355 lb. per sq. ft. for every foot of head.

STANDARD SPECIFICATIONS FOR CEMENT.

General Conditions.

1. All cement shall be inspected.
2. Cement may be inspected either at the place of manufacture or on the work.
3. In order to allow ample time for inspecting and test-

ing, the cement should be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the contractor and a period of at least 12 days allowed for the inspection and necessary tests.

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 lb. of cement net. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

8. Cement failing to meet the 7-day requirements may be held awaiting the results of the 28-day tests before rejection.

9. All tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society January 21, 1903, and amended January 20, 1904, with all subsequent amendments thereto. (See addendum to these specifications.)

10. The acceptance or rejection shall be based on the following requirements:

NATURAL CEMENT.

11. **Definition.** This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Specific Gravity.

12. The specific gravity of the cement thoroughly dried at 100° C., shall be not less than 2.8.

Fineness.

13. It shall leave by weight a residue of not more than 10% on the No. 100, and 30% on the No. 200 sieve.

Time of Setting.

14. It shall develop initial set in not less than 10 minutes, and hard set in not less than 30 minutes, nor more than 3 hours.

Tensile Strength.

15. The minimum requirements for tensile strength for briquettes 1 in. square in cross section shall be within the following limits, and shall show no retrogression in strength within the periods specified:*

Age.	Neat Cement.	Strength.
24 hours in moist air		50-100 lb.
7 days (1 day in moist air, 6 days in water)		100-200 lb.
28 days (1 day in moist air, 27 days in water)		200-300 lb.
	One Part Cement, Three Parts Standard Sand.	
7 days (1 day in moist air, 6 days in water)		25- 75 lb.
28 days (1 day in moist air, 27 days in water)		75-150 lb.

Constancy of Volume.

16. Pats of neat cement about 3 in. in diameter, ½ in. thick at center, tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(a) A pat is then kept in air at normal temperature.

(b) Another is kept in water maintained as near 70° F. as practicable.

17. These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, should remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

PORTLAND CEMENT.

18. **Definition.** This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3% has been made subsequent to calcination.

Specific Gravity.

19. The specific gravity of the cement, thoroughly dried at 100° C., shall be not less than 3.10.

Fineness.

20. It shall leave by weight a residue of not more than 8% on the No. 100, and not more than 25% on the No. 200 sieve.

Time of Setting.

21. It shall develop initial set in not less than 30 min-

*For example, the minimum requirement for the 24 hour neat cement test should be some value within the limits of 50 and 100 lb., and so on for each period stated.

utes, but must develop hard set in not less than 1 hour, nor more than 10 hours.

Tensile Strength.

22. The minimum requirements for tensile strength for briquettes 1 in. square in section shall be within the following limits, and shall show no retrogression in strength within the periods specified:*

Age.	Neat Cement.	Strength.
24 hours in moist air		150-200 lb.
7 days (1 day in moist air, 6 days in water)		450-550 lb.
28 days (1 day in moist air, 27 days in water)		550-650 lb.
	One Part Cement, Three Parts Sand.	
7 days (1 day in moist air, 6 days in water)		150-200 lb.
28 days (1 day in moist air, 27 days in water)		200-300 lb.

Constancy of Volume.

23. Pats of neat cement about 3 in. in diameter, ½ in. thick at the center, and tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(b) Another pat is kept in water maintained as near 70° F. as practicable, and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for five hours.

24. These pats, to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Sulphuric Acid and Magnesia.

25. The cement shall not contain more than 1.75% of anhydrous sulphuric acid (SO_3), nor more than 4% of magnesia (MgO).

ADDENDUM.

ABSTRACT OF METHODS RECOMMENDED BY THE SPECIAL COMMITTEE ON UNIFORM TESTS OF CEMENT OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

Sampling.

1. Selection of Sample: The sample shall be a fair av-

*For example, the minimum requirement for the 24 hour neat cement test should be some value within the limits of 150 and 200 lb., and so on for each period stated.

Percent of Water for Cement Mortars of Normal Consistency.

(Suggested by American Society for Testing Materials.)

Percentage of Water for Neat Cement	Percentage of Water for Sand Mortars — Proportions Cement to Sand by Weight					Percentage of Water for Neat Cement	Percentage of Water for Sand Mortars — Proportions Cement to Sand by Weight				
	1:1	1:2	1:3	1:4	1:5		1:1	1:2	1:3	1:4	1:5
18	12.0	10.0	9.0	8.4	8.0	33	17.0	13.3	11.5	10.4	9.6
19	12.8	10.2	9.2	8.5	8.1	34	17.3	13.6	11.7	10.5	9.7
20	12.7	10.4	9.3	8.7	8.2	35	17.7	13.8	11.8	10.7	9.9
21	13.0	10.7	9.5	8.8	8.3	36	18.0	14.0	12.0	10.8	10.0
22	13.8	10.9	9.7	8.9	8.4	37	18.3	14.2	12.2	10.9	10.1
23	13.7	11.1	9.8	9.1	8.5	38	18.7	14.4	12.3	11.1	10.2
24	14.0	11.3	10.0	9.2	8.6	39	19.0	14.7	12.5	11.2	10.3
25	14.3	11.6	10.2	9.3	8.8	40	19.3	14.9	12.7	11.3	10.4
26	14.7	11.8	10.3	9.5	8.9	41	19.7	15.1	12.8	11.5	10.5
27	15.0	12.0	10.5	9.6	9.0	42	20.0	15.3	13.0	11.6	10.6
28	15.3	12.2	10.7	9.7	9.1	43	20.3	15.6	13.2	11.7	10.7
29	15.7	12.5	10.8	9.9	9.2	44	20.7	15.8	13.3	11.9	10.8
30	16.0	12.7	11.0	10.0	9.3	45	21.0	16.0	13.5	12.0	11.0
31	16.3	12.9	11.2	10.1	9.4	46	21.3	16.1	13.7	12.1	11.1
32	16.7	13.1	11.3	10.3	9.5						

erage of the contents of the package; it is recommended that, where conditions permit, one barrel in every 10 be sampled.

2. All samples should be passed through a sieve having 20 meshes per linear in., in order to break up lumps and remove foreign material; this is also a very effective method for mixing them together in order to obtain an average. For determining the characteristics of a shipment of cement, the individual samples may be mixed and the average tested; where time will permit, however, it is recommended that they be tested separately.

3. **Method of Sampling:** Cement in barrels should be sampled through a hole made in the center of one of the staves, midway between the heads, or in the head, by means of an auger or a sampling iron similar to that used by sugar inspectors. If in bags, it should be taken from surface to center.

Chemical Analysis.

4. **Method:** As a method to be followed for the analysis of cement, that proposed by the Committe on Uniformity in the Analysis of Materials for the Portland Cement Industry, of the New York Section of the Society for Chemical Industry, and published in the Journal of the Society for January 15, 1902, is recommended.

Specific Gravity.

5. **Apparatus and Method:** The determination of specific gravity is most conveniently made with Le Chatelier's apparatus. This consists of a flask (*D*), Fig. 1, of 120 cu. cm. (7.32 cu. in.) capacity, the neck of which is about 20 cm. (7.87 in.) long; in the middle of this neck is a bulb (*C*), above and below which are two marks (*F*) and (*E*); the volume between these marks is 20 cu. cm. (1.22 cu. in.). The neck has a diameter of about 9 mm. (0.35 in.), and is graduated into tenths of cubic centimeters above the mark (*F*).

6. Benzine (62° Baume naphtha), or kerosene free from water, should be used in making the determination.

7. The specific gravity can be determined in two ways:

(1) The flask is filled with either of these liquids to the lower mark (*E*) and 64 gr. (2.25 oz.) of powder, previously dried at 100° C. (212° F.) and cooled to the temperature of the liquid, is gradually introduced through the funnel (*B*) [the stem of which extends into the flask to the top of the bulb (*C*)], until the upper mark (*F*) is reached. The difference in weight between the cement

remaining and the original quantity (64 gr.) is the weight which has displaced 20 cu. cm.

8. (2) The whole quantity of the powder is introduced, and the level of the liquid rises to some division of the

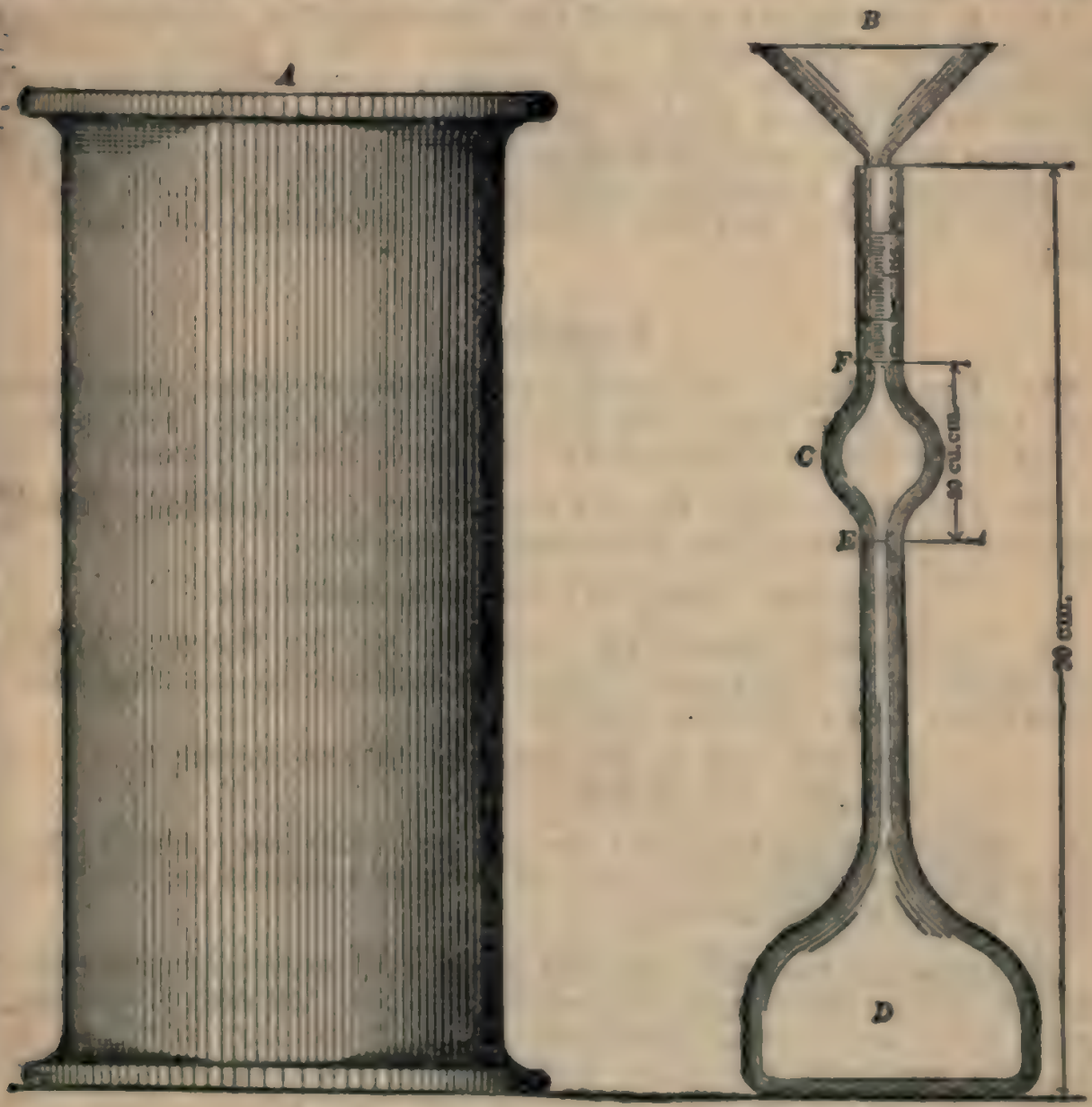


Fig. 1. Le Chatelier's Apparatus.

graduated neck. This reading plus 20 cu. cm. is the volume displaced by 64 gr. of the powder.

9. The specific gravity is then obtained from the formula:

$$\text{Specific Gravity} = \frac{\text{Weight of Cement}}{\text{Displaced Volume.}}$$

10. The flask, during the operation, is kept immersed in water in a jar (*A*), in order to avoid variations in the temperature of the liquid. The results should agree within 0.01.

11. A convenient method for cleaning the apparatus is as follows: The flask is inverted over a large vessel, preferably a glass jar, and shaken vertically until the liquid starts to flow freely; it is then held still in a vertical position until empty; the remaining traces of cement can be removed in a similar manner by pouring into the flask a small quantity of clean liquid and repeating the operation.

Fineness.

12. **Apparatus:** The sieves should be circular, about 20 cm. (7.87 in.) in diameter, 6 cm. (2.36 in.) high, and provided with a pan, 5 cm. (1.97 in.) deep, and a cover.

13. The wire cloth should be woven (not twilled) from brass wire having the following diameters:

No. 100, 0.0045 in.; No. 200, 0.0024 in.

14. This cloth should be mounted on the frames without distortion; the mesh should be regular in spacing and be within the following limits:

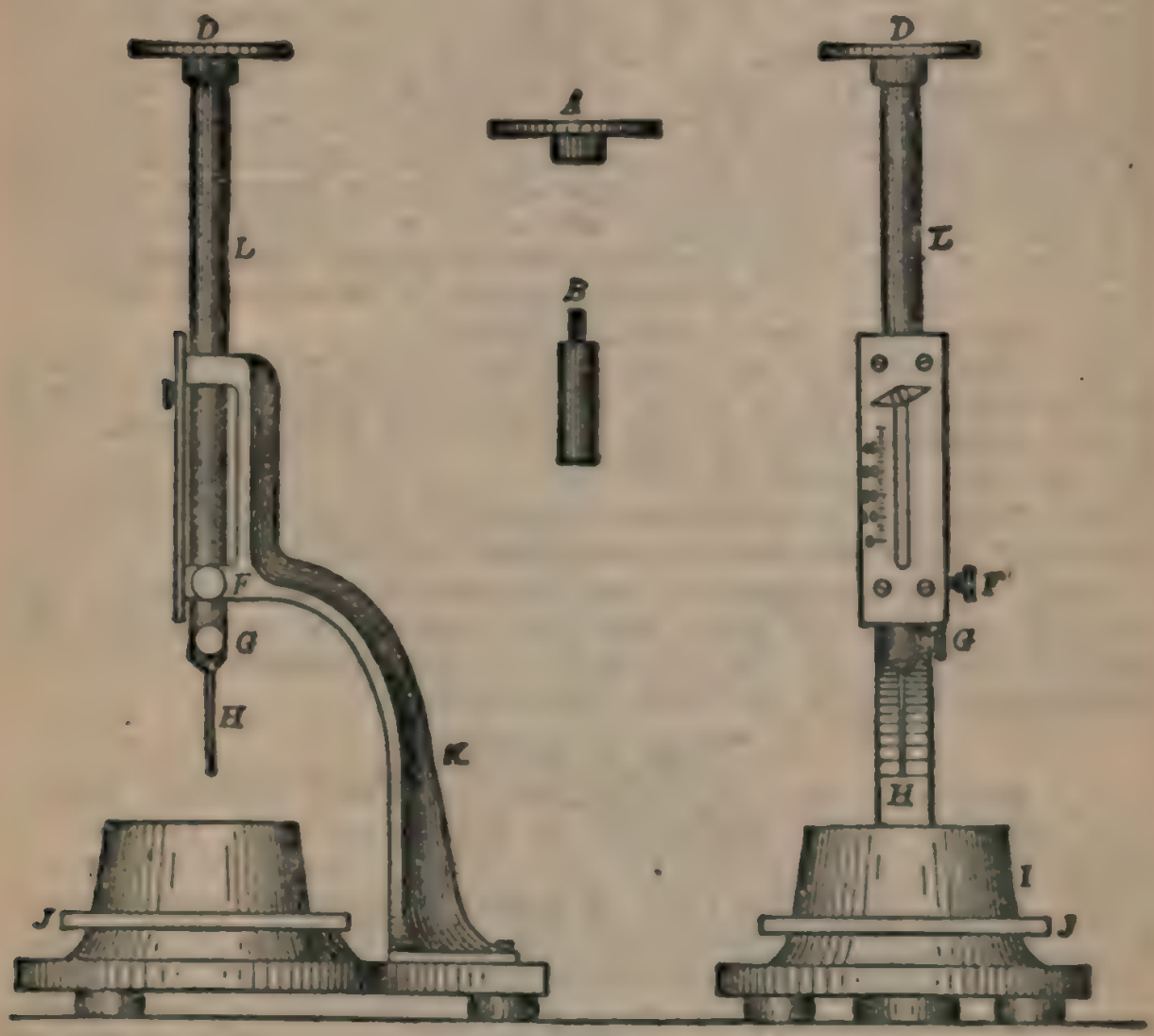
No. 100, 96 to 100 meshes to the linear in.
No. 200, 188 to 200 " " " "

15. Fifty gram. (1.76 oz.) or 100 gr. (3.52 oz.) should be used for the test, and dried at a temperature of 100° C. (212° F.) prior to sieving.

16. **Method:** The thoroughly dried and coarsely screened sample is weighed and placed on the No. 200 sieve, which, with pan and cover attached, is held in one hand in a slightly inclined position, and moved forward and backward, at the same time striking the side gently with the palm of the other hand, at the rate of about 200 strokes per minute. The operation is continued until not more than one-tenth of 1 per cent passes through after one minute of continuous sieving. The residue is weighed, then placed on the No. 100 sieve and the operation repeated. The work may be expedited by placing in the sieve a small quantity of large shot. The results should be reported to the nearest tenth of 1 per cent.

Normal Consistency.

17. **Method:** This can best be determined by means of Vicat Needle Apparatus, which consists of a frame *K*,



VICAT NEEDLE.

Fig. 2.

Fig. 2, bearing a movable rod *L*, with the cap *A* at one end, and at the other the cylinder *B*, 1 cm. (0.39 in.) in diameter, the cap, rod and cylinder weighing 300 gr. (10.58 oz.). The rod, which can be held in any desired position by a screw *F*, carries an indicator, which moves over a scale (graduated to centimeters) attached to the frame *K*. The paste is held by a conical, hard-rubber ring (I), 7 cm. (1.76 in.) in diameter at the base, 4 cm.

(1.57 in.) high, resting on a glass plate *J*, about 10 cm. (3.94 in.) square.

18. In making the determination, the same quantity of cement as will be subsequently used for each batch in making the briquettes (but not less than 500 grams) is kneaded into a paste, as described in paragraph 39, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained 6 in. apart; the ball is then pressed into the rubber ring, through the larger opening, smoothed off, and placed (on its large end) on a glass plate and the smaller end smoothed off with a trowel; the paste, confined in the ring, resting on the plate, is placed under the rod bearing the cylinder, which is brought in contact with the surface and quickly released.

19. The paste is of normal consistency when the cylinder penetrates to a point in the mass 10 mm. (0.39 in.) below the top of the ring. Great care must be taken to fill the ring exactly to the top.

20. The trial pastes are made with varying percentages of water until the correct consistency is obtained.

Note. The Committee on Standard Specifications inserts the table on page 121 for temporary use to be replaced by one to be devised by the Committee on the American Society of Civil Engineers.

Time of Setting.

21. **Method:** For this purpose the Vicat Needle, which has already been described in paragraph 17, should be used.

22. In making the test, a paste of normal consistency is molded and placed under the rod *L*, Fig. 2, as described in paragraph 18; this rod, bearing the cap *D* at one end and the needle *H*, 1 mm. (0.039 in.) in diameter, at the other, weighing 300 gr. (10.58 oz.). The needle is then carefully brought in contact with the surface of the paste and quickly released.

23. The setting is said to have commenced when the needle ceases to pass a point 5 mm. (0.20 in.) above the upper surface of the glass plate, and is said to have terminated the moment the needle does not sink visibly into the mass.

24. The test pieces should be stored in moist air during the test; this is accomplished by placing them on a rack over water contained in a pan and covered with a damp

cloth, the cloth to be kept away from them by means of a wire screen; or they may be stored in a moist box or closet.

25. Care should be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point reduces the area and tends to increase the penetration.

26. The determination of the time of setting is only approximate, being materially affected by the temperature of the mixing water, the temperature and humidity of the air during the test, the percentage of water used, and the amount of molding the paste receives.

Standard Sand.

27. For the present, the Committee recommends the natural sand from Ottawa, Ill., screened to pass a sieve having 20 meshes per linear inch and retained on a sieve having 30 meshes per linear inch; the wires to have diameters of 0.0165 and 0.0112 in., respectively, i. e., half the width of the opening in each case. Sand having passed the No. 20 sieve shall be considered standard when not more than 1 per cent passes a No. 30 sieve after one minute continuous sifting of a 500-gram sample.

28. The Sandusky Portland Cement Company, of Sandusky, Ohio, has agreed to undertake the preparation of this sand and to furnish it at a price only sufficient to cover the actual cost of preparation.

Form of Briquette.

29. While the form of the briquette recommended by a former Committee of the Society is not wholly satisfactory, this Committee is not prepared to suggest any change, other than rounding off the corners by curves of ½-in. radius.

Molds.

30. The molds should be made of brass, bronze or some equally non-corrodible material, having sufficient metal in the sides to prevent spreading during molding.

31. Gang molds, which permit molding a number of briquettes at one time, are preferred by many to single molds; since the greater quantity of mortar that can be mixed tends to produce greater uniformity in the results. The type shown in Fig. 4 is recommended.

32. The molds should be wiped with an oily cloth before using.

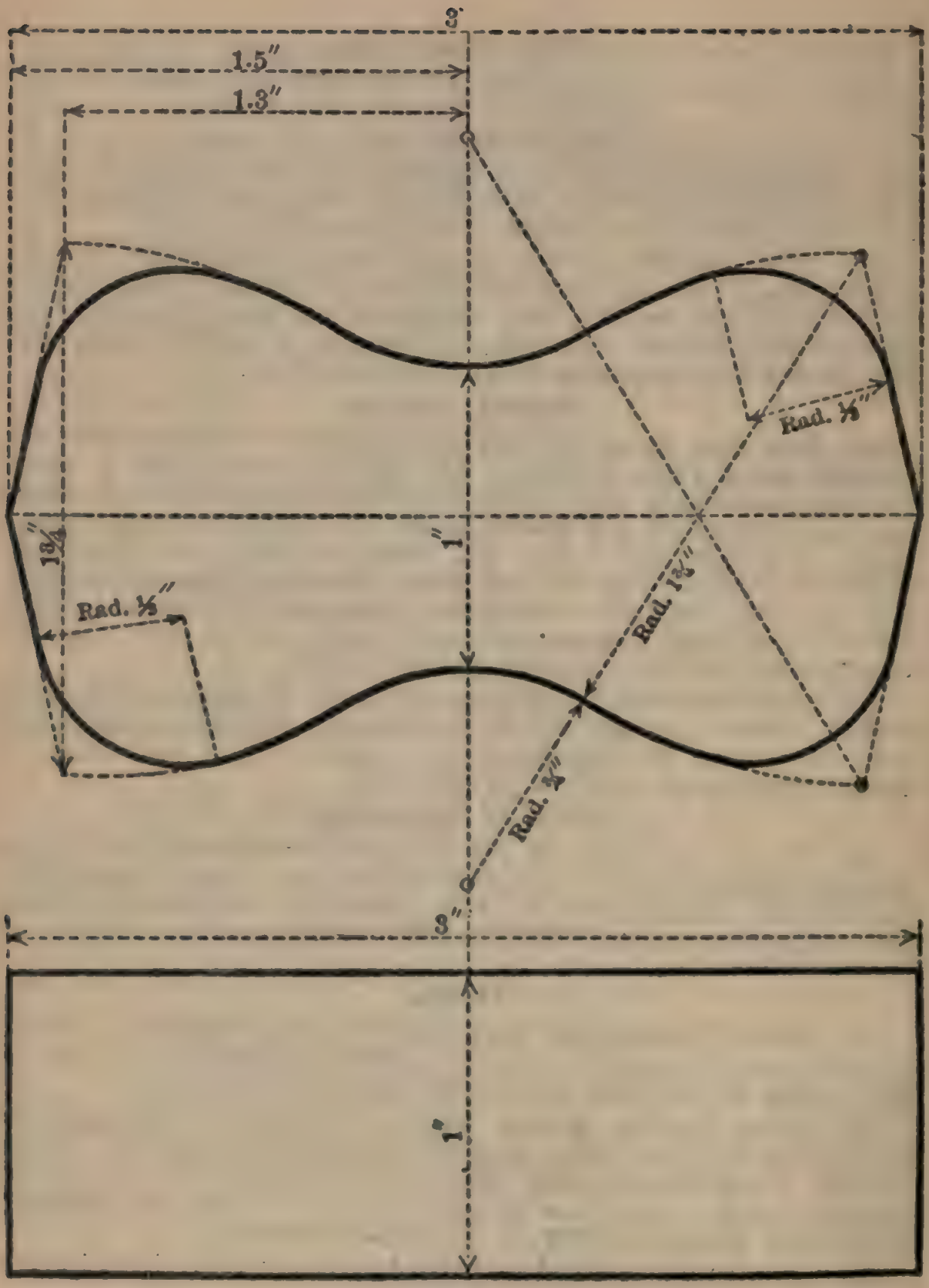


Fig. 3.

Mixing.

33. All proportions should be stated by weight; the quantity of water to be used should be stated as a percentage of the dry material.

34. The metric system is recommended because of the convenient relation of the gram and the cubic centimeter.

35. The temperature of the room and the mixing water should be as near 21° C. (70° F.) as it is practicable to maintain it.

36. The sand and cement should be thoroughly mixed dry. The mixing should be done on some non-absorbing surface, preferably plate glass. If the mixing must be done on an absorbing surface it should be thoroughly dampened prior to use.

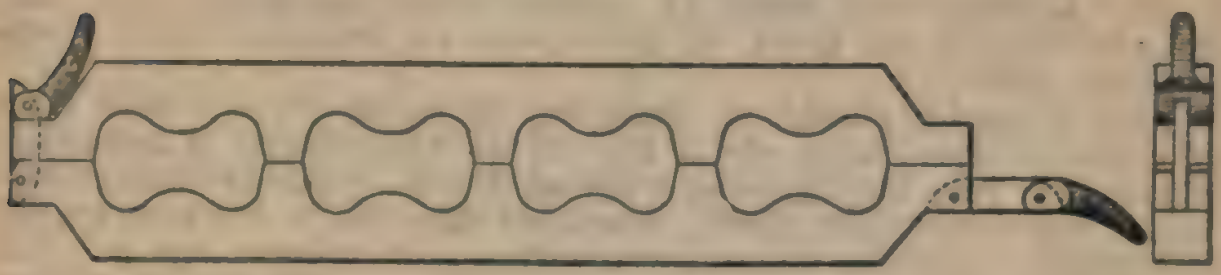


Fig. 4.

37. The quantity of material to be mixed at one time depends on the number of test pieces to be made; about 1,000 gr. (35.28 oz.) makes a convenient quantity to mix, especially by hand methods.

38. **Method.** The material is weighed and placed on the mixing table, and a crater formed in the center, into which the proper percentage of clean water is poured; the material on the outer edge is turned into the crater by the aid of a trowel. As soon as the water has been absorbed, which should not require more than one minute; the operation is completed by vigorously kneading with the hands for an additional 1½ minutes, the process being similar to that used in kneading dough. A sand-glass affords a convenient guide for the time of kneading. During the operation of mixing, the hands should be protected by gloves, preferably of rubber.

Molding.

39. Having worked the paste or mortar to the proper consistency, it is at once placed in the molds by hand.

40. **Method:** The molds should be filled at once, the material pressed in firmly with the fingers and smoothed off with a trowel without ramming; the material should be heaped up on the upper surface of the mold, and, in smoothing off, the trowel should be drawn over the mold in such a manner as to exert a moderate pressure on the excess material. The mold should be turned over and the operation repeated.

44. A check upon the uniformity of the mixing and molding is afforded by weighing the briquettes just prior to immersion, or upon removal from the moist closet. Briquettes which vary in weight more than 3 per cent from the average should not be tested.

Storage of the Test Pieces.

42. During the first 24 hours after molding, the test pieces should be kept in moist air to prevent them from drying out.

43. A moist closet or chamber is so easily devised that the use of the damp cloth should be abandoned if possible. Covering the test pieces with a damp cloth is objectionable, as commonly used, because the cloth may dry out unequally, and in consequence the test pieces are not all maintained under the same condition. Where a moist closet is not available, a cloth may be used and kept uniformly wet by immersing the ends in water. It should be kept from direct contact with the test pieces by means of a wire screen or some similar arrangement.

44. A moist closet consists of a soapstone or slate box, or a metal-lined wooden box—the metal lining being covered with felt and this felt kept wet. The bottom of the box is so constructed as to hold water, and the sides are provided with cleats for holding glass shelves on which to place the briquettes. Care should be taken to keep the air in the closet uniformly moist.

45. After 24 hours in moist air, the test pieces for longer periods of time should be immersed in water maintained as near 21° C. (70° F.) as practicable; they may be stored in tanks or pans, which should be of non-corrodible material.

Tensile Strength.

46. The tests may be made on any standard machine. A solid metal clip, as shown in the figure, is recommended.

This clip is to be used without cushioning at the points of contact with the test specimen. The bearing at each point of contact should be ¼ in. wide, and the distance between the center of contact on the same clip should be 1¼ in.

47. Test pieces should be broken as soon as they are removed from the water. Care should be observed in centering the briquettes in the testing machine, as cross-strains, produced by improper centering, tend to lower the breaking strength. The load should not be applied too suddenly, as it may produce vibration, the shock from which often breaks the briquette before the ultimate strength is reached. Care must be taken that the clips

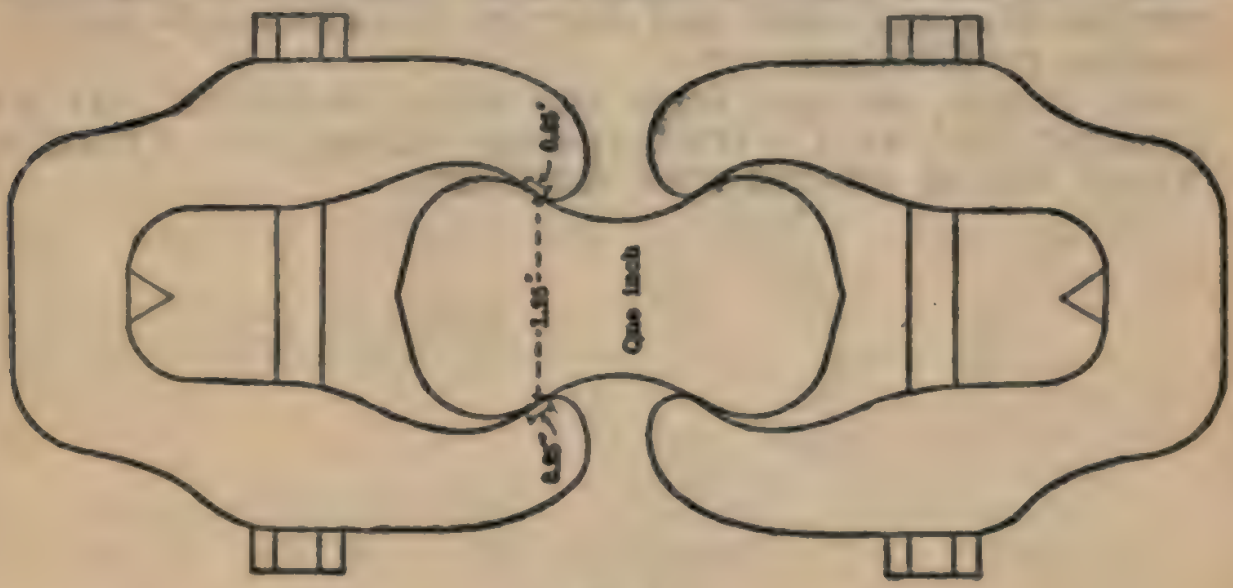


Fig. 5.

and the sides of the briquette be clean and free from grains of sand or dirt, which would prevent a good bearing. The load should be applied at the rate of 600 lb. per minute. The average of the briquettes of each sample tested should be taken as the test, excluding any results which are manifestly faulty.

Constancy of Volume.

48. **Methods:** Tests for constancy of volume are divided into two classes: (1) normal tests, or those made in either air or water maintained at about 21° C. (70° F.), and (2) accelerated tests, or those made in air, steam or water at a temperature of 45° C. (115° F.) and upward. The test pieces should be allowed to remain 24 hours in moist air before immersion in water or steam, or preservation in air.

49. For these tests, pats about 7½ cm. (2.95 in.) in diameter, 1¼ cm. (0.49 in.) thick at the center, and tapering to a thin edge, should be made, upon a clean glass plate [about 10 cm. (3.94 in.) square], from cement paste of normal consistency.

50. **Normal Test:** A pat is immersed in water maintained as near 21° C. (70° F.)) as possible for 28 days, and observed at intervals. A similar pat is maintained in air at ordinary temperature and observed at intervals.

51. **Accelerated Test:** A pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel.

52. To pass these tests satisfactorily, the pats should remain firm and hard, and show no signs of cracking, distortion or disintegration.

53. Should the pat leave the plate, distortion may be detected best with a straight-edge applied to the surface which was in contact with the plate.

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